ICAR-CRIDA & MANAGE, HYDERABAD

Tools on Monitoring, Evaluation and Impact Assessment of Rainfed Agricultural Programs

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This e-book is a compilation of resource text obtained from various subject experts for MANAGE – ICAR-CRIDA collaborative training program on "Tools on Monitoring, Evaluation and impact assessment of Rainfed agricultural Programs" Conducted from 14-16 December, 2021. This e-book is designed for researchers, academicians, extension workers, research scholars and students engaged in Natural Resource Management, Rainfed Agriculture, etc.

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Published for Dr.P.Chandra Shekara, Director General, National Institute of Agricultural Extension Management (MANAGE), Hyderabad, India by Dr. Srinivasacharyulu Attaluri, Program Officer, MANAGE and printed at MANAGE, Hyderabad as e-publication.

MESSAGE

ICAR-Central Research Institute for Dryland Agriculture is a premier national research institute under the Indian Council of Agricultural Research (ICAR), Ministry of Agriculture and Farmers Welfare, New Delhi with a mandate to carry out basic and applied research in rainfed farming. ICAR-CRIDA is also working closely with different stakeholders towards the development of climate resilient agriculture in India. It is a pleasure to note that, ICAR-CRIDA, Hyderabad and MANAGE, Hyderabad, Telangana is organizing a collaborative training program on Tools on Monitoring, Evaluation and Impact Assessment of Rainfed Agricultural Programs and coming up with a joint publication as e-book on "Tools on Monitoring, Evaluation and Impact Assessment of Rainfed Agricultural Programs" as immediate outcome of the training program.

As we know, monitoring, evaluation and impact assessment have become integral part of a project management to ensure that the project progresses as planned and results in impacts that are expected. In the simplest terms, monitoring involves a periodical review of the project in terms of budgets spent, resources used and other milestones met as specified in the project plan. On the other hand, evaluation involves examining whether the project has achieved its objectives in terms of whether the intended impacts are achieved and how big or small these impacts are in relation to those actually intended to be achieved. Thus, monitoring and evaluation share the common goal of enhancing project effectiveness, efficiency and sustainability of the impacts.

I wish the program be very purposeful and meaningful to the participants and also the e-book will be useful for stakeholders across the country. I extend my best wishes for success of the program. I would like to compliment the efforts of Course Director's from ICAR-CRIDA and MANAGE for this valuable publication.

Dr. V. K. Singh

Director, ICAR-CRIDA

PREFACE

This e-book is an outcome of collaborative online training program on **"Tools on Monitoring, Evaluation and Impact Assessment of Rainfed Agricultural Programs**". It is a result of collective efforts, experience and knowledge and wisdom of several authors. This book is intended for extension professionals and department officials who are key players in the development and implementation of various agricultural programs. Bringing views of experts from different fields of agriculture through this training programme suffice opportunities for cross-learnings among trainees.

Monitoring and evaluation are important management tools to check the progress of a particular programme and facilitate decision-making. It can help organization extract relevant information from past and ongoing activities that can be used as the basis for pragmatic fine-tuning, reorientation and future planning. Looking into theme of the training, experts from ICAR-CRIDA, MANAGE and ICAR-NAARM have been called for providing a common platform for the officials involved in the field of agriculture to understand the subject. We wish to place on record the cooperation and support received from all the authors and staff at ICAR-CRIDA, MANAGE and ICAR-NAARM who contributed in various ways for timely publication of this book. This book has enlightened the social impacts of watershed programmes, the problem driven iterative adoption for solving developmental problems, impact of development interventions in government schemes, digital tools for monitoring and evaluation, statistical tools for impact assessment and evaluation, impact assessment of KVK, ORPS and AICRPDA network and other related topics.

The valuable suggestions for future improvements are always welcome.

December, 2021 **Editors**

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ROLE AND IMPORTANCE OF MONITORING, EVALUATION AND IMPACT ASSESSMENT OF AGRICULTURAL DEVELOPMENT

V. K. Singh

Director, ICAR-Central Research Institute for Dryland Agriculture, Hyderabad

Introduction

Agriculture lies at the centre of many sustainable development goals and therefore development of agriculture is critical to achieve progress towards attainment of those goals. But agricultural development requires to deal with many different challenges in the dimensions of social, environmental, economic and international relations. Interventions in the spheres of research, policy, institutions and trade have to be carefully designed and implemented for more sustainable agricultural development.

Enhancing human welfare is the ultimate goal of development planning by the governments and other organizations. Investments, use of physical, material and human resources, are planned and executed with a view to achieve certain objectives. These investments often take place in the form of 'projects'. A project can be described as a set of well thought out sequence of activities aimed at achieving some pre-defined objectives within a specified time-frame. The benefits from a project can flow for a particular time period or sometimes can even be for a very long time. However, the fundamental principle of economics says that resources are always limited relative to the ends they are supposed to meet. Thus, there is a need to allocate and use resources in a manner that maximizes the utility. When the resources being spent belong to the society, it is even more needed to ensure that the resources are spent properly. Thus, there is an increasing need for using the resources available in the most efficient manner.

Many public investments are bundled in the form of projects. Though these can be classified as either economic or environmental based on the purpose, most projects have a combination of economic, environmental and social effects. When the environmental effects are dominant, they can be called environmental projects. It is however difficult to imagine projects that have economic effects or environmental effects solely. After all, the very existence of human beings is critically dependent on the health of the environment around.

Fortune & White (2006) describe a sustainable investment project as a discrete investment activity, with a specific starting point and a specific ending point, intended to accomplish specific economic, social and environmental objectives simultaneously. It comprises a well-defined sequence of investments, which are expected to result in a stream of specific benefits over time. World Bank Group (1996) defines a project as a capital investment for developing facilities in order to provide goods and services, while United States Environmental Protection Agency (2002) states that a project involves the utilization in the near future of scarce or at least limited resources in the hope of obtaining in return some benefits over a long period of time.

In order to ensure that the project progresses as planned and results in impacts that are expected, monitoring, evaluation and impact assessment have become integral part of project management. In the simplest terms, monitoring involves making a periodical review of the project in terms of budgets spent, resources used and other milestones met as specified in the project plan. It can also involve assessing the impacts that might have been expected while the project is still in progress. Evaluation on the other hand involves examining whether the project has achieved its objectives in terms of whether the intended impacts are achieved and how big or small these impacts are in relation to those actually intended to be achieved.

Usually, the project evaluation is done at three different stages of a project. At the beginning of the project, an evaluation of the project is done based on certain informed assumptions regarding the possible impacts and the temporal flow of these benefits. Such an exercise is referred to as *ex ante* evaluation. This analysis, when done for different candidate projects, will be useful in selecting a set of projects that are likely to maximize the returns to investment. Monitoring, on the other hand, is done during the course of the project and evaluation is done at the end of the project and is called *ex post* evaluation.

Monitoring

As mentioned earlier, monitoring is done while the project is being implemented in order to take measures that will enhance the effectiveness of the project activities. It involves all levels of management and comprises both planned reports on progress and routine intra-project communications as well as the learning that occurs. It can either be done by an independent third-party agency or by the implementing or funding agency. In any case, involvement of the implementing agency in monitoring is important as the purpose is to accept that lessons that will enable mid-course corrections. In fact, it is desirable to have a monitoring plan in the project proposal itself in terms of the variables to be monitored, any intermediate impacts likely to be created, the definition and/ description of these variables to be monitored along with the measurement methods and sources of data, periodicity of monitoring and the persons or agencies responsible for undertaking this activity.

Evaluation

Evaluation refers to the process of establishing facts about if the intended objectives of the project are met and the degree to which these objectives are met. The project proposal should specify the impacts that are expected from the project activities in terms of the nature and quantum of impact and the target regions and / or groups of people. Both *ex ante* evaluation and monitoring will provide useful links to the final evaluation of the project. Though monitoring and evaluation have traditionally been seen as two different activities, the recent thinking considers both as a part of a single system concerned with improvement of project design and execution.

The evaluation of any project basically involves comparison of costs associated with implementation of the project and the costs and benefits accrued attributable to the project. While the identification of the costs associated with the project implementation are relatively easier, identification of costs and benefits that result out of the project activities can prove to be challenging, especially when the project interventions affect the environment. This is what distinguishes monitoring and evaluation of the environmental projects from that of other projects.

Any evaluation programme must be able to examine (i) whether and how the project activities are relevant in the specified area or target groups, (ii) whether the intended results have been achieved and what activities of the project have been responsible for the results and the reasons for non-achievement of results, (iii) whether the resources have been spent in the best possible way and the scope for improvement in the efficiency (iv) whether the resulting impacts have been of the desired magnitude and are relevant to achieve the longer term goals that the project is supposed to address and (v) whether and how the project continues to have positive impact even after completion. It is also important to deal with the reasons for success or failure of the project in the evaluation report so that the relevant learnings can be taken to designing the subsequent projects.

Both monitoring and evaluation share the common goal of enhancing project effectiveness, efficiency and sustainability of the impacts. Thus, a proper monitoring and evaluation is possible only when they are given adequate importance at the project planning itself. It is also important that the project implementing agency own such a monitoring and evaluation plan so that the learnings are acted up on more readily.

The purpose of monitoring and evaluation can be summarized as below:

1. To ensure that planned objectives or results are achieved
2. To strengthen the project management

3. To enable common understanding about the project among different stakeholders
4. To contribute to better understanding and to advance the project design and execution
5. To ensure transparency and accountability, and
6. To mobilize public and political support

Both monitoring and evaluation depend heavily on the indicators of performance. In case of monitoring, the relevant indicators can be obtained both from within the project execution unit and from the area of action. The former contains indicators related to financial progress and physical progress and the latter contains information on the relevant outputs, outcomes and impacts depending on the nature of the project. The indicators selected are to be relevant, measurable, responsive to the project interventions, stable, and acceptable to the stakeholders.

In case of evaluation, the costs and benefits associated with project activities have to be identified, quantified and monetized before they are compared to make a comment on the viability of the project. There is a clear need to identify the boundaries of the project intervention. The comparison can be made either following a 'with and without' approach or a 'before and after' approach or a combination of the two. In case of environmental projects, developing counterfactual scenario as to what would have happened in the absence of the project in question may sometimes be more relevant and useful. The following are some of the key steps in execution of a project evaluation:

- Put in place a plan for evaluation as part of a larger M&E plan. This also involves having a bench mark survey done to capture the information at the beginning of the project.
- Identify the key interventions and the impacts that they are expected to create in terms of key indicators (e.g. crop yield, crop acreage, water table depth, etc), target locations and human groups.
- Determine the temporal flow of costs and benefits
- Specify how these indicators are to be measured.
- Identify the spatial and temporal externalities and if possible, quantify them.
- Monetize all the negative and positive impacts
- Compute project worth measures such as net present value (NPV), benefit-cost ratio (BCR), internal rate of return (IRR) etc (see Gittinger (1982) for details).
- Perform a sensitivity analysis of these economic measures with a range of numbers for key impact indicators

- Give a description of all those impacts which are difficult to quantify (e.g. downstream effects of soil erosion control, protecting the biodiversity of a region etc)

Impact Assessment

Impact assessment essentially means the effects of a planned intervention(s), that often take the shape of a project or policy, on the targeted population, area, ecosystem, etc. The effects can be economic, environmental, social. A properly planned impact assessment will be comprehensive evaluation of effects on all the spheres. Consideration of spatial and temporal dynamics of the impacts will be more useful for designing programmatic or project interventions for more sustainable and equitable outcomes and impacts.

Building a baseline or counterfactual, identifying the indicators of impact, understanding the impact pathways, measuring the changes in impact indicators, valuation of the changes in impact indicators and finally attributing the changes to the project or intervention are various steps in impact assessment. A properly planned impact assessment will (i) help quantify the benefits arising from the project interventions (ii) help improve planning and designing future projects or interventions (iii) inform decision making on resource allocation to alternative projects and (iv) help mobilize support of policy makers, donors and stakeholders.

Impact indicators vary with the nature, type and scale of interventions attempted as part of a given project. At the farm level, changes in crop yield and production, animal productivity, fodder availability, water availability, cropping intensity, use of labour and other inputs etc. are some of the more common indicators. Interventions such as soil and water conservation, rainwater harvesting, soil health management etc. lead to improvements in water holding capacity, ground water availability, organic carbon, etc. but with a time lag. Therefore, periodicity of measurement of changes in different indicators is to be determined taking such issues into consideration. If the project under consideration is of a large scale, changes in production, prices and trade of agricultural commodities constitute indicators of change.

Impact assessment is ideally done by a third party but with collaboration and cooperation of the project implementing agencies so that the learnings from impact assessment (as well as from monitoring and evaluation) can be appropriately followed up and acted up on.

Approaches to economic valuation of impacts

The process of evaluation of environmental projects is served immensely by what is popular as Environmental Impact Assessment (EIA). The development of natural resource economics as a specialized area of interest within economics has contributed immensely to identification and valuation of costs and benefits associated with an environmental project. EIA coupled with evaluation of impacts can aid in selecting the best-bet project among the alternatives, assessing the utility and viability of the activities that an EIA might have suggested at the project formulation stage and finally in performing an economic evaluation of the project after completion.

When the impacts include the changes in production and productivity only, it is relatively easier to identify, quantify and monetize using economic theory and relevant methods such as economic surplus analysis (For details about this method, see Alston et al (1995). When the impacts also include significant environmental changes, it becomes difficult to identify and to put an economic value on those benefits. There have been evolved a number of approaches and methods in the recent past to quantify the economic value of environmental impacts or services. The following are some of the approaches and methods that will be of relevance and use while evaluating environmental impacts.

- When the production changes are significant and result in price changes also, non-distorted market prices can be used wherever available. If the latter are not available, one can use surrogate market approaches, apply shadow prices.
- When the environmental changes are related to altering or relocating existing habitats, approaches such as opportunity cost approach, replacement cost approach, land value approach or contingent evaluation may be followed.
- Travel cost approach and contingent evaluation methods are applied in case of environmental effects related to recreation facilities.
- Replacement or relocation cost approach and use of estimated costs associated with prevention of ill-effects on human health can be followed in case of projects affecting air and water quality. Approaches like the human capital, loss of earnings and medical costs are used when the projects have significant implications to human health. Cost effectiveness analysis is also applied in case of the projects influencing certain environmental and health aspects. This analysis is especially relevant when deciding on the choice of alternative projects with the same goal. For example, if a given acreage of crop land can be brought under irrigation by several different projects, cost effectiveness analysis is more relevant. The technique is also useful when quantifying the economic value is more difficult as, for instance, in case of those projects involving altering or relocating the existing religious places.

While conducting an economic evaluation of environmental projects is more technical and needs significant capacity, it is equally important and useful to involve stakeholders in the process. Some of these economic measurements can be supplemented with a set of easily measurable indicators that the stakeholders can easily understand and appreciate. Involvement of stakeholders in identification and measurement of such indicators will enhance the acceptance of the results of project evaluation by donors, implementing agencies and the political leadership as well. If such indicators-based evaluation is strongly correlated with the more formal measurements, it is even possible to save efforts on the latter especially when the capacity or resources available for a formal evaluation are limited.

Examples of indicators of agricultural projects with considerable environmental effects

1. Watershed or Natural Resource Management: crop productivity (change and variability), ground water status, availability of drinking water, irrigation, cropping intensity, fodder availability etc
2. Biodiversity: Number of crop and weed species observed, number of animal species (including insect species) observed in a given ecosystem, number of species saved from extinction, etc
3. Integrated Pest Management: Reduction in the quantity of chemical insecticides, natural enemies of insect pests observed within a given crop or cropping system, diversity within a crop field (due to inter-crop, trap crop, barrier crop etc), reduced sickness related to exposure to chemical insecticides etc
4. Irrigation: Area irrigated, crop yields, cropping pattern, cropping intensity, habitat lost because of inundation, assets lost, power generation, etc
5. Climate change: Emissions per unit of output, yield stability or resilience, reduction in erosive coping, etc.

Some other issues

Even if one has given the most possible care and attention in drawing up a proper monitoring and evaluation plan, the following bottlenecks can still be encountered.

- As already mentioned, monitoring and impact assessment are skill intensive and it is difficult to find human resources capable of performing this task. Investment should therefore be made in capacity building.
- The project management should provide for adequate financial and other resources even from the beginning of the project so that the project performance can be enhanced. Mechanisms to act up on the learnings arising from the monitoring should be put in place.
- It is sometimes difficult to define a time horizon on the flow of benefits from the project. In such cases, it is a usual practice to include the annuity value of the benefits flowing

into perpetuity which may result in a bias. Also, selection of discount rates while computing the project worth measures may prove to be challenging.

- There is a need to be careful about selecting indicators of impact. It is desirable to select those indicators that are directly influenced by the project interventions. For example, it is better to assess the impact on the crop yield rather than on profits if the intervention is related to change in management practice. If yield gains are accompanied by price decline, higher profits are not ensured in which case tracking profits would give a different picture though the interventions are successful.
- Economic analysis is limited in its scope and capacity to arrive at economic measures on the benefits when the project activities interfere with the cultural, religious, ethical and traditional value systems.
- It is to be borne in mind that it is difficult to draw a physical and temporal boundary to the impacts on environment that some projects might lead to. Therefore, it is more important to define the conceptual and analytical boundaries for the evaluation framework so that the results are taken with that aspect in mind.

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CONCEPTS AND PRINCIPLES OF MONITORING AND EVALUATION

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Introduction

Monitoring and evaluation can help organization extract relevant information from past and ongoing activities that can be used as the basis for programmatic fine-tuning, reorientation and future planning. Without effective planning, monitoring and evaluation, it would be impossible to judge if work is going in the right direction, whether progress and success can be claimed, and how future efforts might be improved. This chapter describes the purposes of planning, monitoring and evaluation in the context of results-based management (RBM) and managing for development results and explains how these functions are important to an organization involved in evaluation process. It also provides key definitions and principles that are integral to planning, monitoring and evaluation.

Monitoring

Monitoring and evaluation are important management tools to track progress and facilitate decision making. (World Bank, 2007). According to World Bank, Monitoring can be defined as a continuing function that aims primarily to provide the management and main stakeholders of an ongoing intervention with early indications of progress, or lack of, in the achievement of results. It involves regular collection of information for timely decision making, ensure accountability, and provide the basis for evaluation and learning. It is a continuous and periodic review and surveillance by management at every level of the implementation of an activity to ensure that input deliveries, work schedules, targeted outputs and other required actions are proceeding according to plan.

It is system of processing of information for management decision making. It is the management function which begins with start of a project and ends with completion of the project but it is continuous process during implementations of the project. The key requirement for monitoring is an Action Plan without which monitoring is not possible (S Rajakutty 2008).

Monitoring techniques generally followed are refereeing to annual reports, monitoring staff performance, tour reports of field staff, reports from visitors, interviews, key informants and complaints and other participatory means involving beneficiaries and project staff discuss and assess the performance together in order to understand how they performed, what the problems are and what future hold for them.

Evaluation

Evaluation is defined as, systematic and objective assessment of an ongoing or completed project, program, or policy and its design, implementation and results. It is intended to determine the relevance and fulfillment of objectives, development efficiency, effectiveness, impact and sustainability.

Evaluation is an assessment of results or impact of a project with reference to the objectives in the project. Evaluation helps to refine our gals. It helps in getting to know the reasons for success or failure of program. It helps to identify the strengths and weaknesses of the program.

There are **four core principles** guiding evaluation matters. These are

1. **Utilization focused - influence and consequence aware**

Evaluation needs to be carried out based utility and actual use of intended users. It will minimize inputs and maximize results. Focusing evaluation on the utilization has influence on the evaluation design and facilitation. Therefore, the emphasis in utilization-focused evaluation is therefore on intended use by intended users. It is also important to be aware of the consequences and influences of evaluation, whether conscious or unconscious. Involving stakeholders in a participatory way can lead to change in mindset of the stakeholder and how they use the results. The consequence of evaluation use can include and bring changes in individuals, interpersonal relationships, and collective change.

2. **Focus on stakes, stakeholder's engagement and learning**

It is an important to engage 'right stakeholders' in evaluation of programme. The right stakeholders involved in project can be assessed employing key questions such as who the stakeholders are, what are the stakes and who has these stakes? Why encourage stakeholder engagement, how much participation and what is the role of self-evaluation, who to engage and what are the consequences of these choices, what evaluation roles are needed in balancing content and people processes? How to engage stakeholders effectively?

While engaging stakeholders it is important to think who, why and what are possible consequences are for their inclusion and exclusion. Stakeholders can learn from each other by sharing, critically reflecting on their own, and other's actions, behaviors, experiences, views and perceptions. Engaging stakeholders in dialogue can be a useful way of finding a common ground and identifying differences. Stakeholders when involved the evaluation process becomes a platform for shared learning, relevant and spur them into action at the beginning to the end.

3. Situational responsiveness

Situational responsiveness involves matching the evaluation design, to the needs, constraints and opportunities of the particular situation. There are no single methods or methodology that is universally applicable. The design of a particular evaluation depends on the people involved and their situation. Situational responsiveness requires constantly look out for the unexpected. Hummelburner 2000 proposes 4 dimensions one has look into while designing evaluation namely theme/ topic of evaluation, Time, social structure and place and location.

4. Multiple evaluation and evaluation roles

An evaluator has to play different roles during evaluation. Besides; different people have different roles to play in evaluation. Some of the roles enlisted are collaborator, trainer, group facilitator, technician, politician, organizational analyst, internal colleague, external expert, methodologist, information broker, communicator, change agent, diplomat, problem solver and consultant.

Logframe Vs The theory of change

The logical framework (log frame) has traditionally been used widely as a tool in development planning to systematically structure development interventions. In recent times, however, other frameworks and approaches have gained popularity, such as the **theory of change**, due in part to the limitations of the log frame. In this theory of change, it uses the same basic elements of the logical framework, which gives broader perspective of the development initiative. A theory of change requires one to have a well-articulated and clear testable hypothesis about how change will occur that will allow one to be accountable for the results.

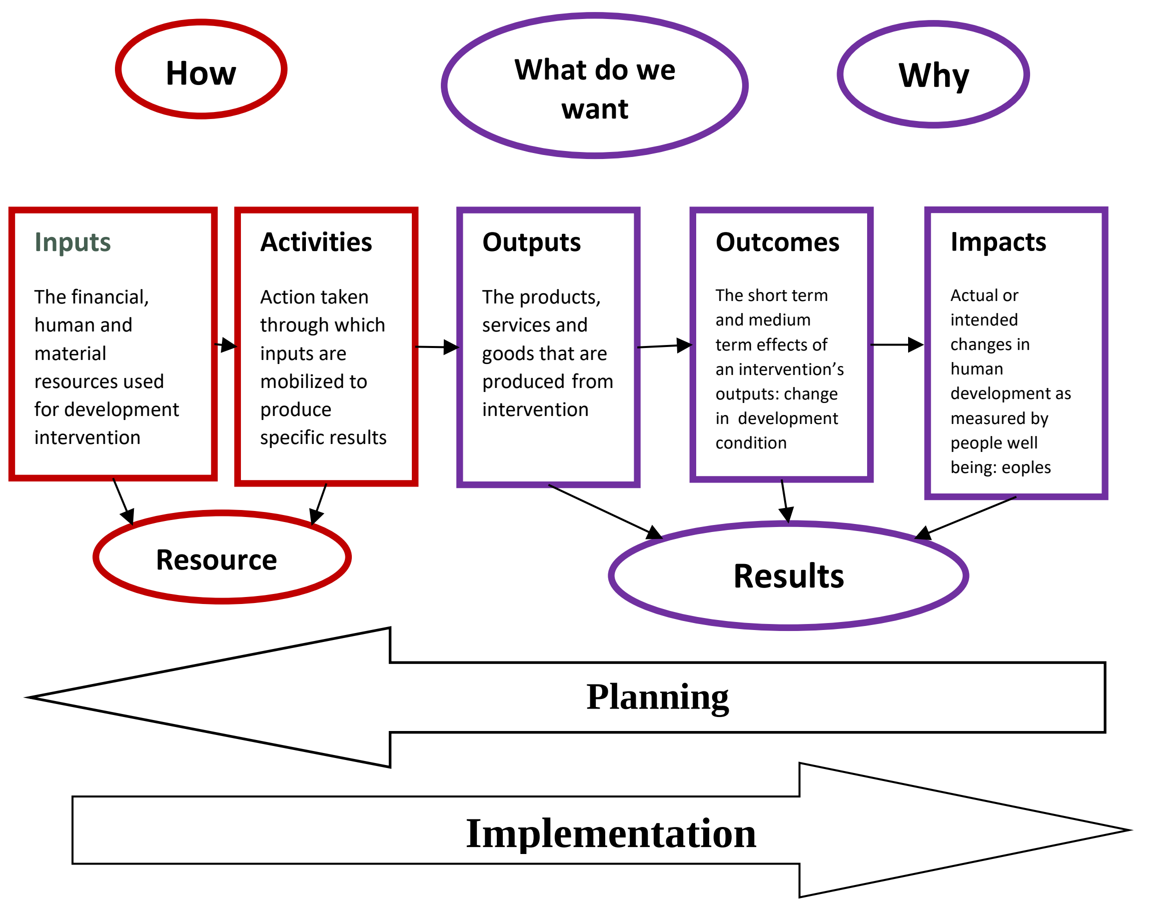
The theory of change can be used to

1. Check milestones,
2. Document lessons about what really happens,
3. Keep the evaluation implementation process transparent and
4. Help prepare reports of findings, policy, etc.

In this theory, critical assumptions will need to be evaluated and more attention to be paid. The different methods of theory of change conceptualization were taught in this training like the deductive approach, inductive approach and user focus approaches. One relatively simple way to develop visualization map of change is by intended cause-effect relationships and underline assumptions. The intended cause-effect relationships should indicate the following key elements as well clarify how they are inter linked and what factors might influence these linkages.

1. **Activities:** What the development initiative sets out to do.
2. **Outputs:** What the development initiative was directly responsible for delivering
3. **Outcomes:** What changes/effects were expected as a result of the outputs. This may include changes in awareness, motivation, skills, knowledge as well as behavior and performance.
4. **Impact:** Changes in socio-economic and/or environmental conditions the programme sought to contribute towards.
5. **Assumptions:** External factors that could affect the progress or success of a development programme. They help to explain the causal linkages. Not all elements of a theory of change can be visualized, for example our values that influence our thinking about how change happen.

Figure 1 Results Based Management Chain (source: UNDP, 2006)



Develop the Evaluation Matrix (EM)

The evaluation matrix usually developed after an initial literature review and discussions with key stakeholders and primary users, or when conceptualizing the theory of change. In doing so, it is important to understand the wider context (environmental, political, economic, etc.) and, if necessary, to work with individuals who do.

The evaluation matrix is defined as a key tool used in designing evaluations and helps you to summarize the implementation of the evaluation process. It assists in focusing the key evaluation questions and clarifying ways in which these key questions will be addressed during the evaluation. Flexibility is required in using this evaluation matrix, particularly where issues are complex in nature and clear objectives and indicators cannot be defined. An example of an evaluation matrix is provided.

Key elements of the evaluation matrix may include:

- **Evaluation focus/key performance areas**: Key areas to be explored during the evaluation
- **Key evaluation questions**: Broad question that help to focus the evaluation on the information needs of the primary intended users of the findings
- **Key information needs**: These may include a range of different types of information to answer the key evaluation questions. Often referred to as indicators but can be broader
- **Baseline information**: What baseline information already exists?
- **Data gathering**: What sources and methods are going to be used for data collection?
- **Planning and resources**: What tools, planning, training, expertise are required and who does what?
- **Information analysis, critical reflection, reporting and feedback**: How will analysis of the findings take place? How will feedback and reporting take place? Who is responsible for what?

Steps to be taken before implementation of Evaluation plan

Step-I - To establish ability and readiness for evaluation

The first domain is the readiness to evaluation. Before implementation of evaluation plan, assessment of ability and preparedness of the team have to be assessed. The second is the focus on evaluation, comprises steps to determine the purpose and scope of evaluation such as agree on the evaluation purpose like the downward accountability or upward accountability. It clearly informs about the evaluator purpose of evaluation, what he intends to achieve, indicates the primary user of information, whether the evaluator likes to inform the donors, manager of programme, which is the upward accountability; or the evaluator wants to show the grass root beneficiaries the utility of program and how the programme benefits reaching them in downward accountability. The third, important evaluation part is the 'Implement the evaluation which comprises of steps: 1) Plan and organize the evaluation, develop evaluation Matrix; identify key indicators and other information needs; identify baseline information; collect and process data; analyse and critically reflect on findings and communicate and make sense of findings.

Step-2: Focus on the evaluation which includes purpose and scope

Under step two of evaluation process, proper clarity on the types of questions the evaluation process need to answer. These questions are related to:

- Who needs what information?
- What are the broad areas of concern for stakeholders?
- What questions need to be addressed?
- How can we summarise the key issues and steps in the evaluation process?

It was mentioned that evaluations often assess impact, relevance, sustainability, effectiveness and efficacy.

- Impact indicated what changes have resulted?
- Relevance painted out the weather doing the right things?
- Sustainability meant whether changes last?
- Efficacy looks into the initiative taken whether the whole programme working as expected?
- Effectiveness indicated whether doing things right? Efficiency indicated the initiative being worthwhile?

Conclusion

Conducting Evaluation as per the procedure would add value and validity to the results of evaluation to any field but it is much particular with agriculture and nutritional security programme. It would also throw light upon the programme implementation, its achievements and constraints so that an appropriate action plan chalked out for addressing constraints in future, if possible and reduce investment and transaction costs.

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PROBLEM DRIVEN ITERATIVE ADOPTION FOR SOLVING DEVELOPMENTAL PROBLEMS MONITORING, EVALUATION, FEEDBACK AND LEARNING

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A problem-driven, iterative approach to institutional reform involves (i) solving defined performance problems through (ii) creating an environment amenable to experimentation, (iii) creating tight feedback loops, and (iv) engaging a broad set of actors. Such an approach has recently been termed as PDIA (problem-driven iterative adaptation), with analysis suggesting that successful institutional reforms have mostly followed PDIA principles, though these may not have been acknowledged explicitly.PDIA (Problem Driven Iterative Adaptation) as an approach to building capability of state organizations while producing results. PDIA is implemnted through four principles given in figure 1.

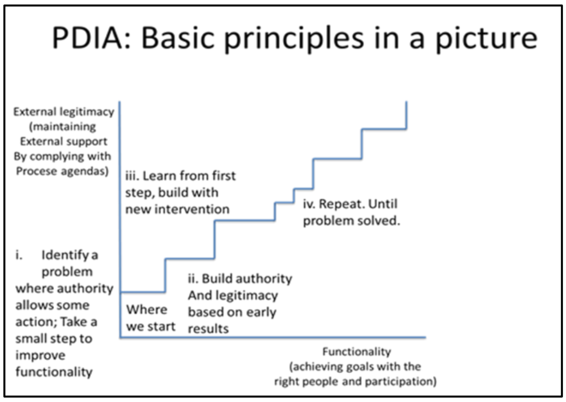


Figure 1: Basic principles of PDIA

Four Principles of PDIA (Problem-Driven Iterative Adaptation)

1. Local Solutions for Local development Problems
2. Authorizing Problem Driven Positive Deviance
3. Try, Learn, Iterate, Adapt
4. Scale Learning through Diffusion

1. Local Solutions for Local development Problems

- ✓ Agenda for action focused on a locally nominated (through some process) concrete problem (through fishbone diagrams)
- ✓ Not “solution” driven that defines the problem as the lack of a particular input (e.g. “lack of micro-nutrients in market”) or process (e.g. “direct money transfer”)

- ✓ Rigorous about measurable goals in the output/outcome space (e.g. increasing farmers' incomes, exports of mangos, growth of exports)—can we know if the problem is being solved?

Fishbone diagram and 5-whys approach for problem diagnosis

We propose using tools like fishbone (Figure 2) diagrams or 5-Way conversations in action tables (table 1) to diagnose local development problems and identify root causes of the problems. These tools emerged from production process theory, especially from the experience of Toyota. Toyota uses the tools to scrutinize problems encountered in making cars, to ensure that any remedies treat the root causes of these problems and allow production facilities to introduce solutions that are sustainable (and mitigate against the recurrence of the problem). This is how real capability is built in the Toyota Corporation (where teams learn to 'encounter a problem, break it down and scrutinize it, solve the root causes, and lock in the solutions so that the problem does not repeat itself'). The tools require those involved in building state capability to ask, repeatedly, 'why' the problem was caused, and then chart the answers in a visual manner to show its many causal roots. This allows one to identify multiple root causes and to interrogate each cause in depth.

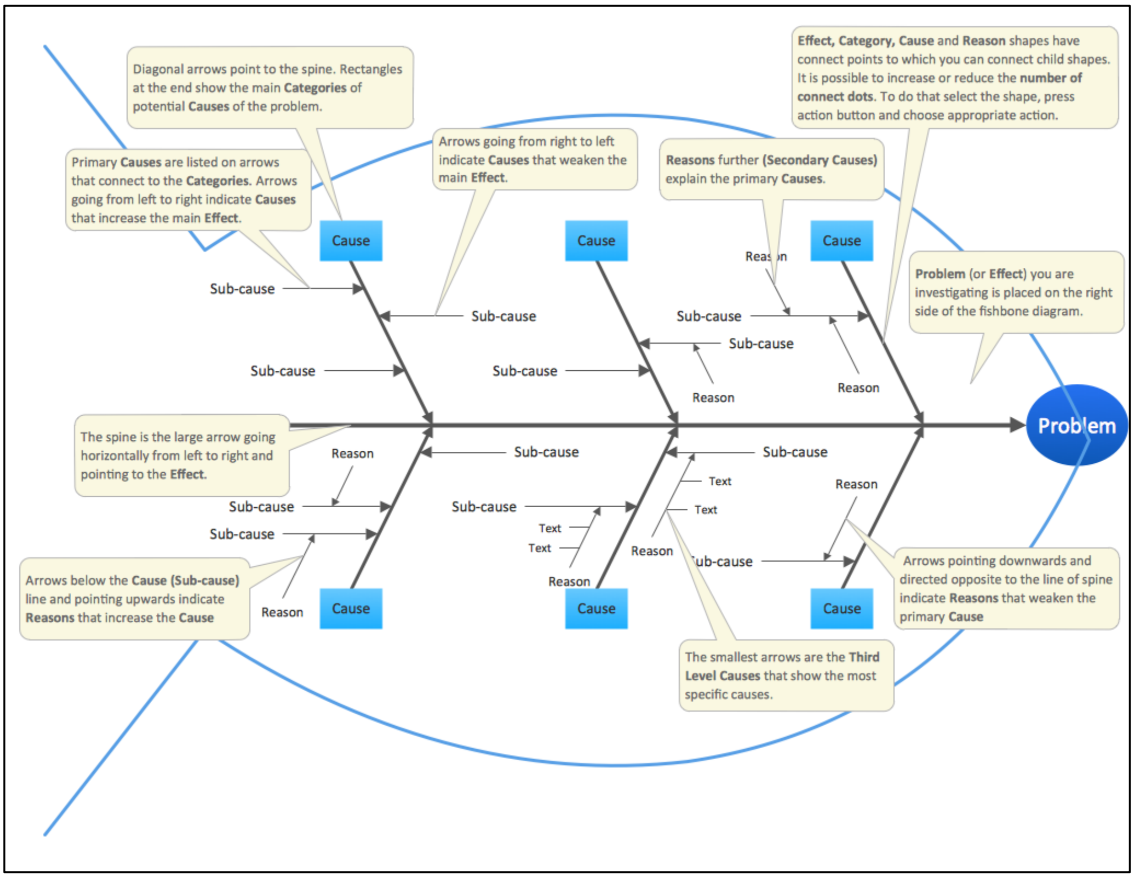


Figure 2: Demonstration of fish-bone diagram for development problem analysis

Most of the developing countries are faced with low service delivery like poor extension services, poor veterinary services and poor health services. Money is being lost in service delivery leading to service delivery failure is a common problem, which needs to be diagnosed for why it was happened in the local context. An example was presented below in terms of 5-why conversations in action (table 1) and fish-bone diagram (figure 3).

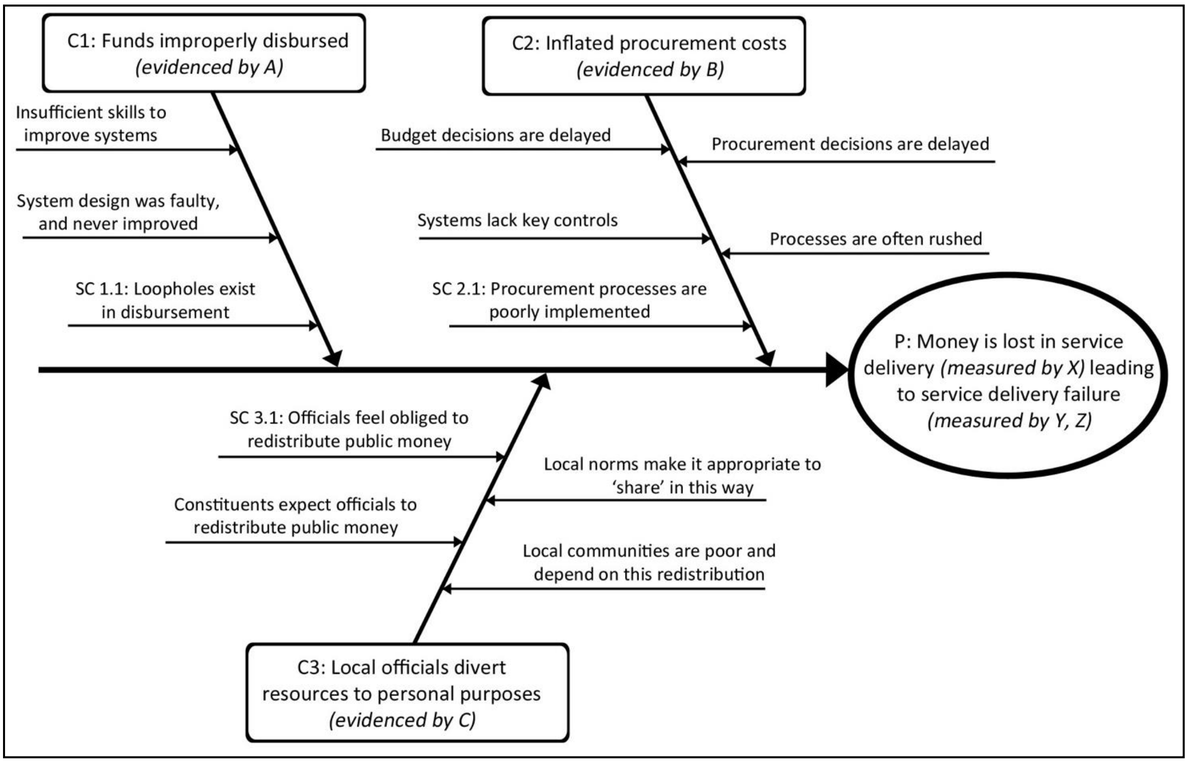


Figure 3: Representing problems in table 1 through fish bone diagram

Table 1: An example of '5 why' conversations in action

	Answer-1	Answer-2	Answer-3
Why is money being lost in service delivery?	Funds budgeted for services are disbursed for other purpose	Procurement costs are inflated, leading to fund leakages	Local officials divert resources to personal purposes
Why does this happen?	Loopholes in disbursement systems allow reallocation	Procurement processes are often half implemented	Officials feel obliged to redistribute money
Why does this happen?	Disbursement systems are missing key controls	Procurement processes are often rushed	Constituents expect officials to redistribute money
Why does this happen?	Disbursement systems were insufficient and have never been improved	Decisions to procure goods are delayed and delayed again, every year	Local norms make it appropriate to share in this way
Why does this happen?	We lack resources and skills to improve system designs	Budget decisions initiating purchase decisions are delayed	Local communities are poor and depend on this sharing

Note: only for demonstration purpose

Diagnosing and deconstructing the problem require answering many questions related to what is the problem? Why does it matter? To whom does it matter? Who needs to care more? How do we get them to give it more attention? What will the problem look like when it is solved? Can we think of what progress might look like in a year, or 6 months? (Table 2)

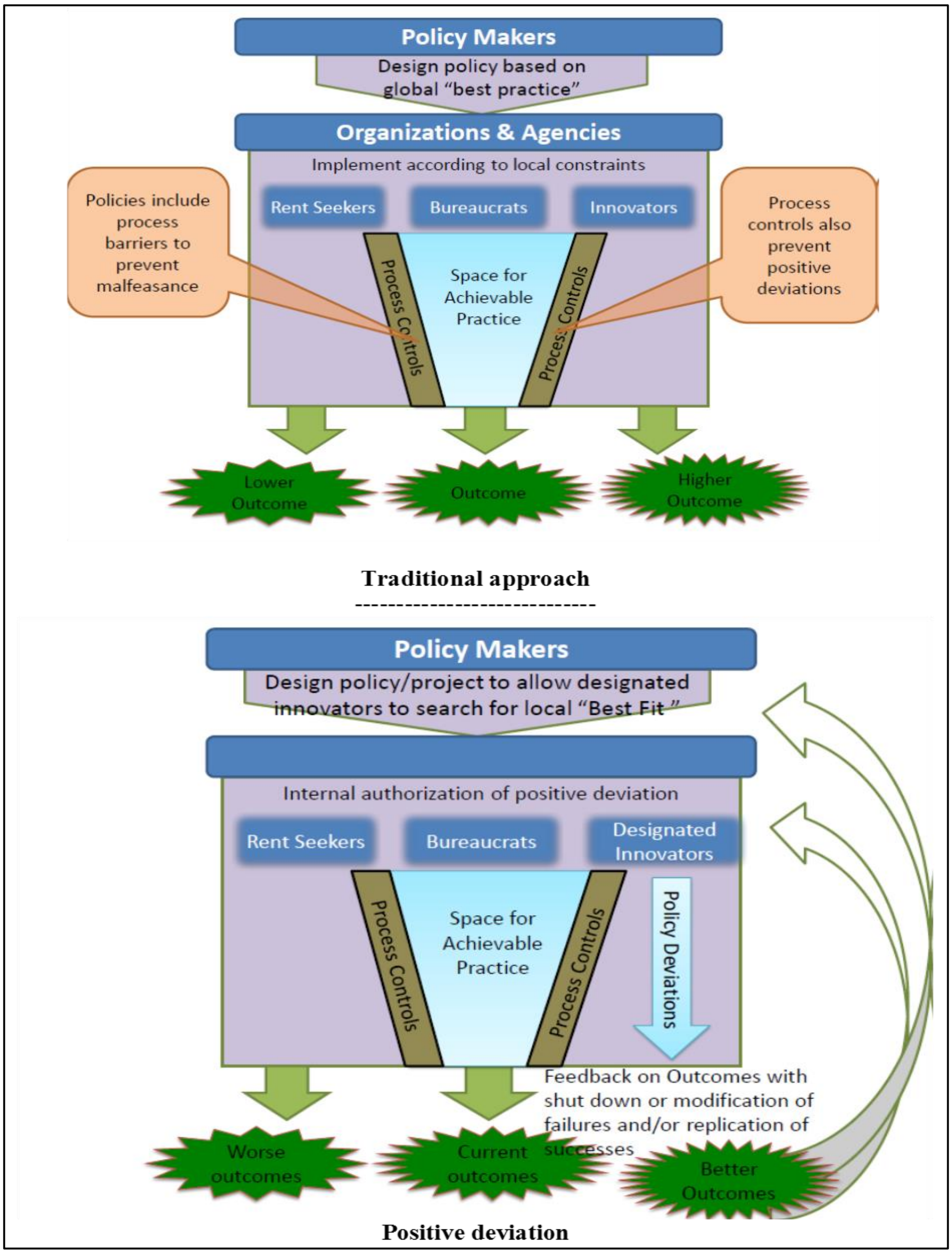
Exercise Table 2: Useful questions for deconstructing the development problems (trainees needs to fill up this table by taking an example local problem)

Questions to be asked	Answer
What is the problem? (And how would we measure it or tell stories about it?)	
Why does it matter? (And how do we measure this or tell stories about it?)	
Why does it matter? (And how do we measure this or tell stories about it?) • Ask this question until you are at the point where you can effectively answer the question below, with more names than just your own	
To whom does it matter? (In other words, who cares? Other than me?)	
Who needs to care more?	
How do we get them to give it more attention?	
What will the problem look like when it is solved? Can we think of what progress might look like in a year, or 6 months?	

Note: trainees may fill it up by taking example of a local burning and urgent problem

2. Pushing Problem Driven Positive Deviation

- ✓ Authorize some agents (not all) to move from process to flexible and autonomous control to seek better results
- ✓ An "autonomy" for "performance accountability" swap (versus "process accountability")
- ✓ Only works if the authorization is problem driven and measured and measurable… "increase farmers income"
- ✓ Allow flexibility in methods against specified and agreed to problems
- ✓ "Fence breaking" activities that allow deviations from process controls for designated activities
- ✓ Rapid feedback loops to search over design space



Traditional approach

Positive deviation

3. Try, Learn, Iterate and adaptation

- ✓ Feedback loops on performance that allow practices to change (rather than stop gap addressing individual cases)
- ✓ Use evidence in management time (not ex post impact evaluation)
- ✓ Have sequenced steps: "what did you do?" "What happened?" "What did you learn?" "What will you do next?"

4. Scaling through diffusion

- ✓ Since the basic problem with dysfunctional organizations is a collapse of internalized norms of performance…this has to be reversed

The table 3 presents the striking differences between conventional M&E approaches and PDIA model.

Table 3: PDIA: a contrast with conventional approach

elements of approach	mainstream development projects/policies/programs	Problem Driven Iterative Adoption
What drives action?	Externally nominated problems or solutions in which deviation from best practice forms is itself defined as the problem	Locally problem driven-looking to solve particular problems
Planning for action	Lots of advance planning, articulating a plan of action, with implementation regarded as following the planned script.	'muddling through' with the authorization of positive deviance and a purposive crawl of the available design space
Feedback loops	Monitoring (short loops, focused on disbursement and process compliance) and Evaluation (long feedback loop on outputs, may be outcomes)	Tight feedback loops based on the problem and on experimentation with information loops integrated with decisions.
Plans for scaling up and diffusion of learning	Top-down-the head learns and leads, the rest listen and follow	Diffusion of feasible practical across organizations and communities of practitioners

Do we always need PDIA?

No. sometimes you can just move ahead with an external solution. It depends on the nature of your task: Is it simple, complicated, or complex?

Where PDIA is applicable?

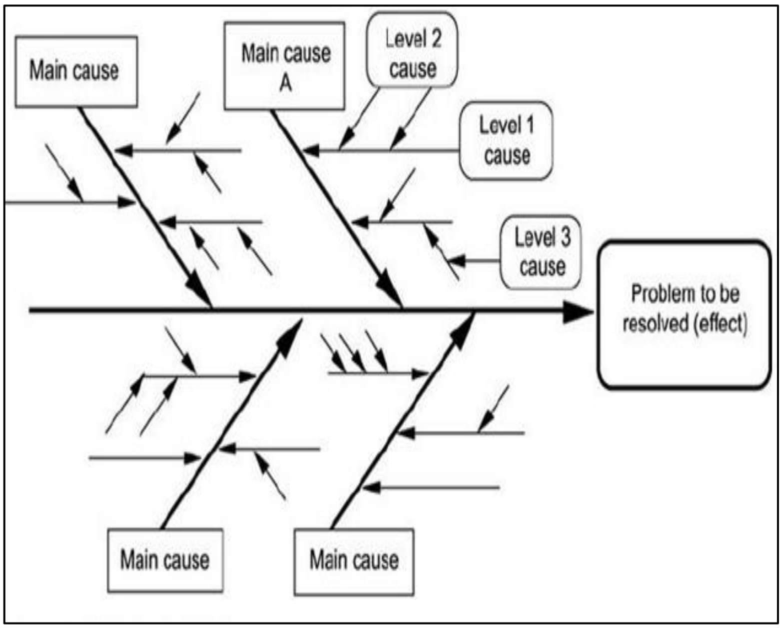
- We have done pretty well with the simple and complicated stuff
- But complex tasks, problems, systems still confound us
    - Challenges with adoption of a promising but complex technology
    - Gaps with adoption of crop insurance (PMFBY)
    - Getting civil servants to use shiny new systems, best practices
- So we need something like PDIA
    - To help us find and fit policy and management solutions
    - That fit the contexts in which we are working

Exercise on 5-Why and fishbone diagram

Annexure 1: Trainees example of '5 why' conversations in action (please fill up this "5-why" to diagnose the local development problems in dryland agriculture

	Answer-1	Answer-2	Answer-3
Problem:			

Why does this happen?			
Why does this happen?			
Why does this happen?			
Why does this happen?			



Annexure 2: Fish bone diagram: Trainees example (to be filled up based on the example table above)

References

Andrews, M., Pritchett, L. and Woolcock, M. (2015). Doing Problem Driven Work. HKS Working Paper No. 073, Pp.47.

MONITORING CLIMATE CHANGE IMPACTS IN LIVESTOCK SECTOR USING INDICATORS OF PRODUCTION AND MANAGEMENT

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Introduction

Effective monitoring and evaluation (M&E) are vital for tracking and measuring any type of assessments of results and throwing light on the impact of development or research interventions. Over the past decade, policy makers and development organizations have faced external pressure to become more effective, and many of them have launched agendas for results-orientation. The international endorsement of the Millennium Development Goals (MDGs) in 2000 has given additional impetus to the quest for results and for demonstrating their achievements. While monitoring and evaluation (M&E) is recognized to be a key element in understanding and effectively tracking and documenting the results of development interventions, it is also admitted that there is a general need to improve M&E in development work. M&E methods and guidelines have received much international attention, but the problems of putting M&E into practice and drawing lessons from field experience, have been less studied.

Livestock rearing is one of the major occupations in rural India and it is making significant contribution to the country's GDP in recent past. The animal husbandry sector has a good growth potential as well as it is an important component to achieve doubling farmer's income. Livestock rearing in India provides manure, draught power for agriculture and local transportation and forms important source of food and cash income to millions of households spread across various parts of the country. So, tracking the progress and monitoring at different level in this sector is very important.

Climate change impacts all sectors of ecosystem; however, such impacts on the basic needs are among the most threatening. Food and nutritional security depend upon our ability to adapt animal-agricultural systems to climate change. Agricultural systems represent the ability to efficiently produce food, feed, and fiber, and disruptions due to climate change impact our capability to feed the future world population. Agricultural systems are multi-faceted and complex because of the range of plant and animal commodities affected by the interactions between climate and management. Recent climate assessments (Melillo *et al*., 2014) incorporate agriculture as one of the key sectors impacted by climate change, and these assessments highlight many of the components vulnerable to climate change and require robust indicators to determine if the impact is increasing and our food and natural resource security is at risk.

Indicators of climate change (CC) can provide a signal of the impact of climate change on animal-agriculture production systems which would be beneficial to the development of strategies for effective adaptation practices. In this chapter, a series of indicators were assembled to determine their potential for assessing animal-agricultural response to climate change in the near term and long term and those with immediate capability of being implemented and those requiring more development. Apart from this, refinement of tools to assess climate impacts on agriculture will provide guidance on strategies to adapt to climate change.

Amongst the other variables, temperature as an important meteorological variable is greatly imposing impacts on livestock in terms of heat stress directly. However, moisture stress and drought affect the fodder as well as grain yields on which livestock production system is dependent. Thus, present chapter has been made to sensitize the stakeholders about how to monitor the climate variability and climate change impacts on livestock using suitable indicators and how to maintain productivity under these circumstances.

Concepts of animal-agricultural systems and climate change

Animal-agricultural systems represent the primary linkage between the climate system and production from grasslands, crops, or livestock (Fig-1). The direct linkages among these components and climate have been summarized in recent articles by Hatfield *et al*., (2011), Izaurralde *et al*., (2011), and Walthall *et al*., (2012). In this conceptual diagram, climate-regulating services, e.g., temperature, carbon dioxide, solar radiation, or precipitation, directly impact grassland, cropping systems, livestock production, and pest dynamics. Precipitation directly affects water supply because of the feedback through the evaporation process which returns water vapour to the climate system (Fig-1). The water cycle is a critical part of agricultural systems, and variation in precipitation governs the amount of water available to the grassland or cropping system. Variation in water availability is direct related to variability in production and is tempered by variation in temperature (Hatfield *et al*., 2011; Izaurralde *et al*., 2011). The potential indicators under this framework relevant to livestock production system directly are increased cold stress and heat stress, however, indirect factors are changes in the length of the growing season, onset of monsoon, yield, quality of feed and fodder etc.

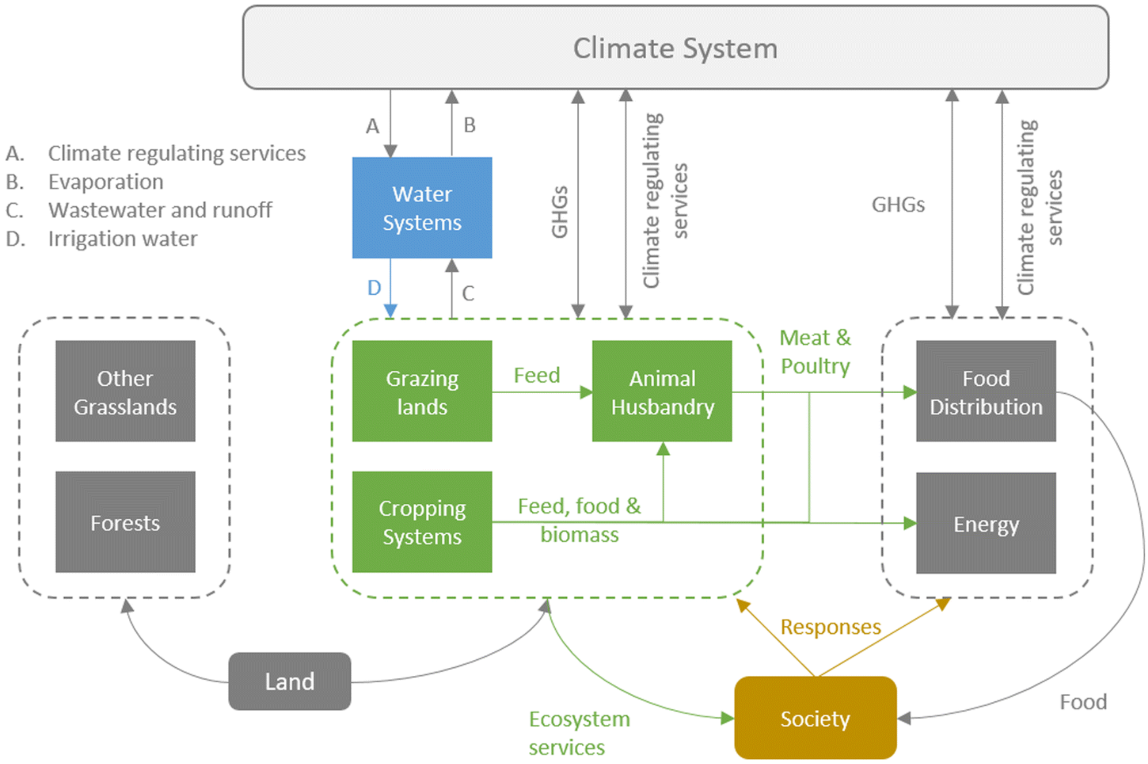

Fig 1: Indicators of climate impacts on animal-agricultural systems (Adopted from Hatfield *et al*., 2020)

Candidate indicators

Indicators meeting these criteria and assessed for their potential as viable indicators to detect agricultural response to climate change are described in Table 1.

Table 1: Indicators of animal-agriculture to climate change

Component	Climate factor	Impact	Indicator
Livestock	Extreme cold/heat stress	Morbidity, mortality, productivity	THI/HLI/Animal based indicators
	Extreme climate events	Morbidity, mortality, productivity	Annual sum of climate index
	Interaction	Disease incidences	Morbidity/ mortality
Soil/water	Intense rainfall	Soil & nutrient loss	Rainfall intensity
	Rainfall	Soil water content	Water availability for crop
Plant	Temperature	Phenology/ growth period	Phenology
	Combinations of temp., humidity, rainfall	Productivity/ biomass/ pests	Productivity/ pest incidence
Economics	Extreme temperature/ precipitation	Loss of productivity/crop-livestock losses	Insurance claims/ indemnities

1. Impact of temperature extremes on livestock

Despite uncertainties in climate variability, the IPCC Fifth Assessment Report identified the “likely range” of increase in global average surface temperature by 2100, which is between 0.3°C and 4.8°C (IPCC, 2013). The potential impacts on livestock include changes in production and quality of feed crop and forage, water availability, animal growth and milk production, diseases, reproduction, and biodiversity. These impacts are primarily due to an increase in temperature and atmospheric carbon dioxide (CO_2) concentration, precipitation variation, and a combination of these factors. The temperature affects most of the critical factors for livestock production, such as water availability, animal production, reproduction and health. Forage quantity and quality are affected by a combination of increases in temperature, CO_2 and precipitation variation. Livestock diseases are mainly affected by an increase in temperature and precipitation variation.

Under heat/cold stress, immediately physiological response followed by behavioural responses of livestock are manifested. Heat stress is one of the most important stressors along with extended periods of high ambient temperature and humidity. In India, livestock begins to suffer from mild heat stress when thermal heat index (THI) reaches higher than 72, moderate heat stress occurs at 80 and severe stress is observed after it reaches 90. There are breed differences also with respect to these THIs. These stresses reduce feed intake and animal productivity in terms of milk yield, body weight and reproductive performance are hampered severely.

More than 50% of milk comes from the buffaloes in India, however, their reproductive performance is severely compromised during summer months is due to inefficiency in maintaining the thermo-regulation under high environmental temperature and relative humidity being poorly developed heat dissipation mechanism in them, a smaller number of sweat glands and dark colour. Heat stress in lactating animals results in dramatic reduction in roughage intake, gut motility and rumination which alters dietary protein utilization and body protein metabolism (Fig-2). Apart from this, high THI can influence disease resistance through lowered feed intake in livestock. There are reports of reduction in feed consumption of poultry birds by 5% for every 1°C rise in temperature between 32-38°C to reduce heat from dissipated in metabolic activities.

Livestock are impacted by climate change, and the potential occurrence of extreme temperature events can disrupt the ability of animals to produce. Economic losses from reduced performance of livestock experiencing severe environmental stress exceed losses associated from livestock death. Exposure to heat stress has a large impact on livestock performance and well-being. Moisture and heat content of the air, thermal radiation, and airflow impact total heat exchange between the atmosphere and an animal. Thus, the effective, or apparent, temperature that an animal responds to is a combination of environmental variables. In the case of humans, the useful effect is the sensation of comfort; for animals, this effect is on performance, health, and well-being.

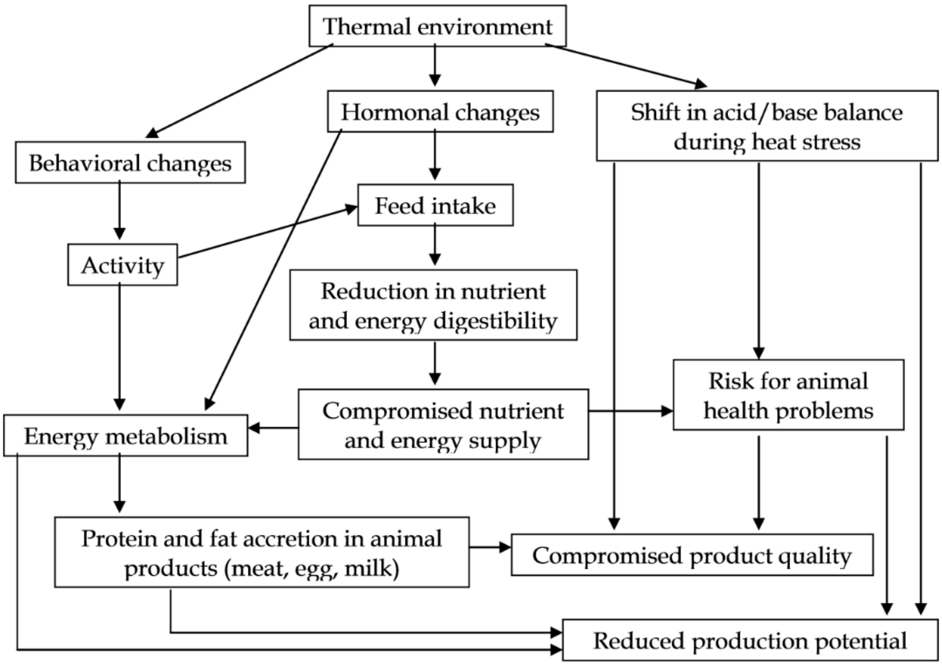

Fig 2: Impact of heat stress in livestock

Indices, because they combine several environmental components, are much more robust for characterizing environmental effects on animal productivity and well-being. To overcome the shortcomings of using ambient temperature as the only indicator of animal stress, thermal indices have been developed to better characterize the influence of multiple environmental variables on the animal. The temperature-humidity index (THI) has been extensively applied in moderate to hot conditions, even with recognized limitations related to airspeed and radiation heat loads. For cold conditions, the wind-chill index (WCI), relating air temperature and wind speed to the time required for freezing a small cylinder of water, serves as a rough guide for measuring cold stress.

These indices are only relevant under either hot or cold conditions, but not both, because simpler indices do not incorporate major environmental components experienced over a range of hot or cold conditions. In addition, appropriate environmental stress thresholds are needed that are flexible and measure stress levels based on environmental conditions, management practices and physiological status. Mader *et al*., (2010) developed the comprehensive climate index (CCI) and comparable thresholds utilizing multiple environmental variables that are incorporated into a continuous index. The CCI incorporates relative humidity, wind speed, and solar radiation to produce an "apparent temperature" that adjusts ambient temperature (Ta) for the effects of environmental variables.

Aside from the benefits of obtaining an apparent temperature for assessing comfort level, climate change effects on livestock can now be assessed over a large range of environmental conditions utilizing the CCI. Physiological and metabolic responses can also be better assessed based on apparent temperature. For strategic decision-making, the CCI can be applied across various life stages and species, in order to maximize the utility of probability information. Multi-factor indices are needed that are comprehensive in nature, which allow for greater application across a range of conditions and have potential for use in assessing environmental effects on animal health, welfare, and productivity. Increased probabilities of extreme events and the impact on livestock productivity increase the potential use of an indicator capable of quantifying the extent of disruption in livestock production. Annual sums of the THI, WCI, or CCI serve as an indicator of the changing environment for livestock for a given location.

2. Impacts on quantity and quality of feeds and water

Quantity and quality of feed might be affected mainly due to an increase in atmospheric CO_2 levels and temperature. The effects of climate change on quantity and quality of feeds are dependent on location, livestock system, and species. Some of the impacts on feed crops and forage are:

• Increase of CO_2 concentration will result in herbage growth changes, with greater effect on C_3 species and less on grain yields. The effects of CO_2 will be positive due to inducing partial closure of stomata, reducing transpiration, and improving some plants' water-use efficiency.

• C_4 species (which account for less than 1% of plants on Earth) are found in warm environments and have higher water-use efficiency than C_3 plants. Temperature increases to 30-35°C could increase herbage growth, with larger effects on C_4 species. However, the effects may vary depending on the location, production system used, and plant species.

• Changes in temperature and CO_2 levels will affect the composition of pastures by altering the species competition dynamics due to changes in optimal growth rates. Plant competition is influenced by seasonal shifts in water availability (Polley *et al*., 2013). Primary productivity in pastures may be increased due to changes in species composition if temperature, precipitation, and concurrent nitrogen deposition increase (IPCC, 2007).

• Quality of feed crops and forage may be affected by increased temperatures and dry conditions due to variations in concentrations of water-soluble carbohydrates and nitrogen.

Temperature increases may increase lignin and cell wall components in plants (Polley *et al*., 2013, Sanz-Saez *et al*., 2012), which reduce digestibility and degradation rates (IFAD, 2010, Polley *et al*., 2013), leading to a decrease in nutrient availability for livestock (Thornton *et al*., 2009). However, as CO_2 concentration rises forage quality will improve more in C3 plants than C4 plants. C3 plants also have greater crude protein content and digestibility than C4 plants (Polley *et al*., 2013, Thornton *et al*., 2009, Wand *et al*., 1999).

• Extreme climate events such as flood, may affect form and structure of roots, change leaf growth rate, and decrease total yield (Baruch and Mérida, 1995).

Impacts on forage quantity and quality depend on the region and length of growing season (Polley *et al*., 2013, Thornton *et al*., 2009). An increase of 2°C will produce negative impacts on pasture and livestock production in arid and semiarid regions and positive impacts in humid temperate regions. The length of growing season is also an important factor for forage quality and quantity because it determines the duration and periods of available forage. A decrease in forage quality can increase methane emissions per unit of gross energy consumed (Benchaar *et al*., 2001). Therefore, if forage quality declines, it may need to be offset by decreasing forage intake and replacing it with grain to prevent elevated methane emissions by livestock (Polley *et al*., 2013).

Global agriculture uses 70% of fresh water resources, making it the world's largest consumer (Thornton *et al*., 2009). However, global water demand is moving towards increased competition due to water scarcity and depletion, where 64% of the world's population may live under water-stressful conditions by 2025 (Rosegrant *et al*., 2002).

Water availability issues will influence the livestock sector, which uses water for animal drinking, feed crops, and product processes (Thornton *et al*., 2009). The livestock sector accounts for about 8% of global human water use and an increase in temperature may increase animal water consumption by a factor of two to three (Nardone *et al*., 2010). To address this issue, there is a need to produce crops and raise animals in livestock systems that demand less water (Nardone *et al*., 2010) or in locations with water abundance.

As sea level rises, more saltwater will be introduced into coastal freshwater aquifers (Karl *et al*., 2009). Salination adds to chemical and biological contaminants and high concentrations of heavy metals already found in waterbodies worldwide and may influence livestock production (Nardone *et al*., 2010). Water salination could affect animal metabolism, fertility, and digestion. Chemical contaminants and heavy metals could impair cardiovascular, excretory, skeletal, nervous and respiratory systems, and impair hygienic quality of production (Nardone *et al*., 2010).

There is a lack of research related to implications of reduced water availability for land-based livestock systems due to climate change (Thornton *et al*., 2009). Therefore, it is important to consider water availability and appropriate mitigation strategies in the context of sustainable livestock production.

3. Livestock morbidity

The effects of climate change on livestock diseases depend on the geographical region, land use type, disease characteristics, and animal susceptibility (Thornton *et al*., 2009). Animal health can be affected directly or indirectly by climate change, especially rising temperatures (Nardone *et al*., 2010). The direct effects are related to the increase of temperature, which increases the potential for morbidity and death. The indirect effects are related to the impacts of climate change on microbial communities (pathogens or parasites), spreading of vector-borne diseases, food-borne diseases, host resistance, and feed and water scarcity (Nardone *et al*., 2010).

Temperature increases could accelerate the growth of pathogens and/or parasites that live part of their life cycle outside of their host, which negatively affects livestock (Harvell *et al*., 2002). Climate change may induce shifts in disease spreading, outbreaks of severe disease, or even introduce new diseases, which may affect livestock that are not usually exposed to these type of diseases (Thornton *et al*., 2009). Evaluating disease dynamics and livestock adaptation will be important to maintain their resilience. Global warming and changes in precipitation affect the quantity and spread of vector-borne pests such as flies, ticks, and mosquitoes. In addition, disease transmission between hosts will be more likely to happen in warmer conditions (Thornton *et al*., 2009). For example, White *et al*., (2003) simulated the impacts of climate change on Australian livestock, finding that livestock lost about 18% of their weight due to increased tick infestations. Wittmann *et al*., (2001) also used a model to simulate the response of *Culicoides imicola* in Iberia, which is the main vector of the bluetongue virus that affects mainly sheep and sometimes cattle, goat, and deer. They reported that the vector would spread extensively with a 2°C increase in global mean temperature. However, these predicted spreads may be prevented by disease surveillance and technologies, such as DNA fingerprinting, genome sequencing, tests for understanding resistance, antiviral medications, cross-breeding, and more (Perry and Sones, 2009; Thornton, 2010). Meanwhile, there is high probability that emergence of new diseases may act as a mixing vessel between human and livestock, facilitating combination of new genetic material and their transmissibility. This makes it difficult to estimate actual disease risk because of the dependence of diseases on animal exposure and interactions factors (Randolph, 2008).

4. Biodiversity

Biodiversity refers to a variety of genes, organisms, and ecosystems found within a specific environment (Swingland, 2001) and contributes to human well-being (MEA, 2005). Populations that are decreasing in genetic biodiversity are at risk, and one of the direct drivers of this biodiversity loss is climate change (UNEP, 2012). Climate change may eliminate 15% to 37% of all species in the world (Thomas *et al*., 2004). Temperature increases have affected species reproduction, migration, mortality, and distribution (Steinfeld *et al*., 2006). The IPCC Fifth Assessment Report states that an increase of 2 to 3°C above pre-industrial levels may result in 20 to 30% of biodiversity loss of plants and animals (IPCC, 2014). By 2000, 16% of livestock breeds (ass, water buffalo, cattle, goat, pig, sheep, and horse) were lost (Thornton *et al*., 2009). In addition, the FAO (2007) has stated that from 7,616 livestock breeds reported, 20% were at risk, and almost one breed per month was being extinguished. Cattle had the highest number of extinct breeds (N=209) of all species evaluated. The livestock species that had the highest percentages of risk of breed elimination were chicken (33% of breeds), pigs (18% of breeds), and cattle (16% of breeds). However, the breeds at risk depends on the region. Developing regions had between 7% and 10% of mammalian species at risk (not restricted to livestock), but between 60% and 70% of mammalian species are classified as of unknown risk. Conversely, in developed regions, where the livestock industry is very specialized and based on a small number of breeds, the mammalian species at risk were between 20% and 28% (FAO, 2007). Thornton *et al*., (2009) states that this biodiversity loss is mainly because of the practices used in livestock production that emphasize yield and economic returns and marginalization of traditional production systems where other considerations are also important (such as ability to withstand extremes).

Livestock and plants will be highly affected by climate change and biodiversity loss. These breeds and species cannot be replaced naturally; therefore, future work that studies the inherent genetic capabilities of different breeds and identifies those that can better adapt to climate conditions is vital.

5. Soil erosion and land use

Soils are a foundation for agricultural production, and soil erosion through water or wind erosion reduces the capacity of the land to efficiently produce feed, food, or fiber. Several processes, both natural and anthropogenic, degrade soils. These processes include erosion, compaction, salinization, toxification, and loss of organic matter. Of these, soil erosion is most directly impacted by climate change and the most pervasive. Excessive rates of erosion decrease soil productivity, increase loss of soil organic carbon and nutrients, and reduce soil fertility.

Soil erosion rates respond to climate change for a variety of reasons, including climatic effects on plant biomass production, plant residue decomposition rates, soil microbial activity, evapotranspiration rates, soil surface sealing and crusting, and shifts in land use necessary to accommodate a new climatic regime (Williams *et al*., 1996). However, the most consequential effect of climate change on water erosion will be in changes in erosive power, or erosivity, of rainfall. Studies using erosion simulation models show that erosion response is much more sensitive to the rainfall amount and intensity than other environmental variables (Nearing *et al*., 1990). Warmer atmospheric temperatures associated with greenhouse warming are expected to lead to a more vigorous hydrological cycle, including more extreme, and hence erosive, rainfall events (Kundzewicz *et al*., 2007). Atmosphere-Ocean Global Climate Models also indicate potential changes in rainfall patterns, with changes in both the number of wet days and the percentage of precipitation coming in intense convective storms as opposed to longer duration, less intense storms.

6. Soil organic matter changes

Soil organic carbon, a key indicator of ecosystem productivity and health, is affected by abiotic and biotic factors. Soil organic carbon monitoring in agricultural fields can serve as an indicator of how agriculture might be affected by climate variability and change and how these effects and changes affect carbon reservoirs as part of mitigation strategies. However, differentiating the interacting effects of climate and management has proven difficult.

Carbon exchanges are not isolated to changes in soil carbon and one indicator with potential value to assess the changes in the land surface is the gross or net primary productivity. These methods are based on either direct measurement of the carbon fluxes over different surfaces using micrometeorological techniques (e.g., Ameriflux, OzFluz) or indirect estimates via remote sensing methodologies (Gitelson *et al*., 2012, 2015). These holds promise as direct methods to measure the impact of climate change on a large scale and require additional assessment of this indicator in response to climate change variables.

7. Crop progress and productivity

Production of food from crops and livestock is necessary to sustain life, and the continual need to produce more food on a global basis to feed the expanding world population increases the potential impact of disruption in production and food security. These projections of food production do not account for the disruptions attributable to climate change and the indirect effects from increasing insect, disease, and weed pressure. Impacts of climate change on plant production can be summarized as being positive under the effects of increasing carbon dioxide (CO_2), negative with effects of increasing temperatures, and variable from precipitation timing and amounts (Hatfield *et al*., 2011; Walthall *et al*., 2012). The effect of increasing CO_2 on plant productivity is generally positive with enhanced production and improved water use efficiency (Hatfield *et al*., 2011).

8. Productivity of agricultural systems

It is the most used indicator of climate impacts (Licker *et al*., 2010; Egli and Hatfield, 2014; van Brussel *et al*., 2015; Hatfield *et al*., 2018). This approach allows for a quantitative assessment of the ability of the crop to achieve its potential yield and the inability of closing the yield gap is ascribed to climatic stress.

Crop production systems respond to the weather conditions within a growing season and over time show responses to changes in the climate (Ray *et al*., 2015). Crop yields are one of the most utilized indicators of the impact of weather during the growing season, and county, state, and national yields have been extensively used to evaluate weather effects through statistical and simulation models.

9. Economic impacts of climate change on agricultural systems

One measure of the potential economic impacts of extreme events within the agricultural sector, as well as an indicator of whether such impacts are increasing as climate conditions change, could be derived from crop-animal insurance claims and payouts. Developing indicators related to the change in the distribution of indemnities provide a quantitative measure of the effect of changing climate; however, not all commodities are crop insurance eligible, so the economic impact is more difficult to assess.

10. Environmental indicators in livestock production systems

The environmental indicators are categorized by environmental factor (soil, water, etc.) and whether the indicator basis is measured from the natural resource base, the livestock present, or the human component. They are in general response indicators, because these can be most easily defined. Under grazing systems, the indicators may be as follows (Table-2):

Table-2. Indicators for livestock production under grazing systems

Category	Natural resource base	Livestock	Socio-economic
Soil/land	Erosion - Universal Soil Loss Equation Presence and use of legumes Manure collection & application practices	Arid: Herd mobility Sub-humid, and humid: Stocking rate and	Arid: Human carrying capacity of the land Land tenure and recent trends in fencing and crop-encroachment in key areas: Vulnerability to

		productivity trends	drought (reliance on food aid) Infrastructure Cohesion of user's groups Diversity of land use
Vegetation	Proportion of ground cover Plant species composition and mosaics, rate between, rate of fire wood collections Presence and use of leguminous plants Utilization of crop aftermath, tame pastures and native rangelands Rate of deforestation	Forage demand Diet preferences Animal productivity & species composition	
Water	Water turbidity Number of boreholes Number of new surface watering points Water quality (nitrate, pesticide content)	Use requirements	
Air	Greenhouse gas balance	Greenhouse gas balance	

Indicators for industrial livestock production systems

The environmental indicators under industrial livestock production system may be input, production or output related as follows (Table-3):

Table 2: Indicators for livestock production under industrialized systems

Input-related	Production-related	Output-related
Land use changes and land requirements for feed production	Conversion efficiencies for N and P by animal species	Manure discharge Nutrient balances
Percentage of grains in concentrates and diet	Farmgate N and P balance	Fertilizing value of manure
Rangeland requirements for young stock	Ammonia emissions	Methane emissions
Livestock breeds used	Methane emissions	Tons of liveweight slaughtered
Inputs to feed production (fuel, fertilizer)	Fossil energy consumption	Tons raw milk
	Animal welfare index	Tons of raw hides processed
	Chemical use	Manure storage

11. Food security

Majority of poor people (about 842 million people; one in eight people worldwide) suffered from hunger during recent past by not receiving enough food to maintain an active and healthy life. Livestock component of agriculture contributes greatly to food security because:

(i) It supplies global calories, proteins, and essential micronutrients,

(ii) It can be productive even in areas that have difficulty growing crops,

(iii) Most of the feed used for livestock rearing are not suitable for human consumption (non-competitors), and

(iv) They provide manure for crop production

However, there are also apprehensions that livestock production is unfavorable to food security. First, the use of grains as feed in livestock production is a worldwide concern because they are produced for animal feed and not for human consumption. Around one-third of the global cereal harvest was used as livestock feed (Steinfeld *et al*., 2006). The bulk of the livestock feed comes from grasses and legume forage that grows on land not suitable to agriculture (O'Mara, 2012), and in many countries, livestock do not receive cereal supplements. In such areas, livestock are a positive contributor to food security. The debate occurs in areas where cattle are pastured in areas perfectly suitable for agriculture, or where they are fed substantial cereal supplements. Second, climate change, mostly via an increase in temperature, may decrease intake of digestible nutrients. Therefore, livestock production may decrease through declining forage quality and quantity and/or by reducing animal feed intake. These two factors affect livestock production because animals will use the available nutrients to first maintain their physiological needs, then for growth or milk production, and finally for reproduction (Hatfield *et al*., 2008). Third, climate change also affects nutritional content of livestock products because of potential increases in pathogens and diseases in their food and effects on the animals themselves (Harvell *et al*., 2002, Karl *et al*., 2009, Patz *et al*., 2000). As new pathogens and diseases emerge and spread, pesticide and veterinary medicine use will change, consequently changing the principal transfer process of environmental contaminants to food (Lake *et al*., 2012).

Sustainable livestock production needs more research, extension, and demonstration. Livestock are an important contributor to food security, but it is important to maintain an efficient conversion of natural resources to human food to sustain a neutral food balance (FAO, 2011). This can be accomplished through efficient production of protein from livestock (FAO, 2013). However, climate change will influence this conversion by affecting the nutritional content of livestock products (Karl et al., 2009) and reducing livestock production (Hatfield *et al*., 2008). Currently, the livestock sector's best approach to contribute to food security is by addressing the primacy of food balance (FAO, 2013).

Climate change and livestock management under field conditions

Most of the resource poor farmers (small and marginal) keep few cattle, goats, sheep and chickens in almost all parts of India. Only some of the progressive farmers who has the resources keep a bigger herd of animals. The livestock are usually fed on crop residues or are allowed to graze nearby which expose them to trace element deficiency as well as broader deficiency known as Hollow Gut Syndrome. Even if the crop fails, the animals can graze on it or animals graze on the harvested fields also. Livestock provide manure for the fields, either by grazing on the stubble after the harvest, or through composting. Special fodder crops are meagerly cultivated due to higher opportunity cost of lands under urbanization scenario. The only viable option, therefore, is to revitalize the degrading common fodder and pasture resources in the country and improve their productivity. Small livestock are a source of ready cash and a safeguard in times of distress to the farmers.

Vast tracts of arid and semi-arid lands are unsuitable for crop production but support livestock, especially small ruminants (sheep and goats). Livestock is not only a vital source of protein but also constitutes an important sector of the economy which makes use of land that would otherwise be unproductive, providing livelihoods to millions of people around the world. In arid and semi-arid regions where crop failures and draught are frequent dependency on livestock increases. Most people depend on the sale of livestock products like milk, meat and hide and livestock itself for their livelihood. Livestock is the main source of food and people different species that cope well with harsh dry environment. The most common and well adapted and acclimatized livestock in these regions are breeds of sheep, goats, camels and cows as per the necessity and purpose to rear these animals.

Climate change may affect the prevalence of parasites and diseases that affect livestock. The change in pattern of onset of monsoon, duration of monsoon, building up of humidity for longer duration, etc. could allow some parasites and pathogens to survive more easily. In areas with increased rainfall, moisture-reliant pathogens could thrive. Increases in CO_2 may increase the productivity of pastures but may also decrease their quality in terms of protein and fibre.

Heat waves, which are projected to increase under climate change, directly impacts the livestock productivity and efficiency. Apart from this, drought reduces the amount of quality forage available to grazing livestock. Some areas could experience longer, more intense droughts, resulting from higher summer temperatures and reduced precipitation. For animals that rely on grain, changes in crop production due to drought could also become a problem.

Conclusion

Monitoring climate change impacts in livestock sector using indicators of production and management consists of animal-based indicator, environment-based indicators and production system-based indicators. We need to observe the different indicators at these three levels, apart from that these bases of indicators are also inter-related where in absence of one, other can also be predicted. Most reliable indicators are animal-based which provide precise information about the impacts. We should have comprehensive knowledge of indicators at all levels to describe the monitorable impacts of climate change.

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STATISTICAL TOOLS FOR IMPACT ASSESSMENT AND EVALUATION

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Introduction

Impact Assessment (IA) is an assessment of change that can be attributed to a particular intervention, such as a project, program or policy. In contrast to outcome monitoring, which examines whether targets have been achieved, impact assessment involves counterfactual analysis. The 'counterfactual' measures what would have happened to beneficiaries in the absence of the intervention, and impact is estimated by comparing counterfactual outcomes to those observed under the intervention. In other words, they look for the changes in outcome that are directly attributable to a program. Counterfactual analysis enables evaluators to attribute cause and effect between interventions and outcomes.

Impact Assessments (IAs) are formal, evidence-based procedures that assess the economic, social, and environmental effects of a project, program or policy (Adelle and Weiland, 2012). Impact assessments can focus on specific themes, such as social impact assessments and gender impact assessments. Impact assessment helps people answer key questions for evidence-based policy making: what works, what doesn't, where, why and for how much? Impact assessment helps by apprising policy makers about potential economic, social, and environmental ramifications.

The International Initiative for Impact Evaluation (3ie) defines Impact Evaluations as: 'analyses that measure the net change in outcomes for a particular group of people that can be attributed to a specific program using the best methodology available, feasible and appropriate to the evaluation question that is being investigated and to the specific context'. It has received increasing attention in policy making in recent years in developing countries. It is an important component of the armoury of evaluation tools and approaches to improve the effectiveness of aid delivery and public spending in improving living standards. Impact evaluation is now being increasingly applied in areas such as the agriculture, energy and transport.

Assessment of Impact

Estimation methods broadly follow evaluation designs. Different designs require different estimation methods to measure changes in outcome from the counterfactual. In experimental and quasi-experimental evaluation, the estimated impact of the intervention is calculated as the difference in mean outcomes between the treatment group (those receiving the intervention) and the control or comparison group (those who don't). This method is also called randomised control trials (RCT). The single difference estimator compares mean outcomes at end-line and is valid where treatment and control groups have the same outcome values at baseline. The difference-in-difference (or double difference) estimator calculates the difference in the change in the outcome over time for treatment and comparison groups, thus utilizing data collected at baseline for both groups and a second round of data collected at end-line, after implementation of the intervention, which may be years later.

Impact evaluations, which have to compare average outcomes in the treatment group, irrespective of beneficiary participation (also referred to as 'compliance' or 'adherence'), to outcomes in the comparison group are referred to as intention-to-treat (ITT) analyses. Impact Evaluations which compare outcomes among beneficiaries who comply or adhere to the intervention in the treatment group to outcomes in the control group are referred to as treatment-on-the-treated (TOT) analyses. ITT therefore provides a lower-bound estimate of impact, but is arguably of greater policy relevance than TOT in the analysis of voluntary programs.

Inferential statistics

Inferential statistics or **statistical induction** comprises the use of statistic (some function of sample values) to make inferences concerning some unknown aspect of a population called parameter. The aim of this section is to draw inferences about a population from a sample.

Sampling distribution: For example, consider a very large normal population (one that follows the so-called bell curve). Assume we repeatedly take samples of a given size from the population and calculate the sample mean ($\bar{x}$, the arithmetic mean of the data values) for each sample. Different samples will lead to different sample means. The distribution of these means is the "sampling distribution of the sample mean" (for the given sample size). This distribution will be normal since the population was normal. According to the central limit theorem, if the population is not normal but "sufficiently well behaved", the sampling distribution of the sample mean will still be approximately normal provided the sample size is sufficiently large. Thus, the mean of the sampling distribution of a statistic is equivalent to the expected value of the statistic. For the case where the statistic is the sample mean:

$$\mu_{\bar{x}} = \mu$$

where μ is the mean of the population distribution of that quantity.

The standard deviation of the sampling distribution of the statistic is referred to as the standard error of that quantity. For the case where the statistic is the sample mean, the standard error is:

$$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$$

where σ is the standard deviation of the population distribution of that quantity and n is the size of the sample (number of items).

Null Hypothesis: It is a statement about population parameters, which is tested for possible rejection under the assumption that it is true.

Although it was originally proposed to be any hypothesis, in practice it has come to be identified with the "nil hypothesis", which states that "there is no phenomenon", and that the results in question could have arisen through chance. For example, if we want to compare paddy yields of two districts, a null hypothesis would be that the mean yield of district-A is same as the mean yield of district-B, and therefore there is no significant statistical difference between them:

$H_0: \mu_1 = \mu_2$

Where H_0 = the null hypothesis

μ_1 (mu 1) = the mean yield in district-A, and

μ_2 (mu 2) = the mean yield in district-B

Alternative Hypothesis: This is complementary to null hypothesis. When a null hypothesis is formed, it is always in contrast to an implicit *alternative hypothesis*, which is accepted if the observed data values are sufficiently improbable under the null hypothesis. The precise formulation of the null hypothesis has implications for the alternative. If one wants to test null hypothesis that mean yield of district-A is same as the mean yield of district-B then alternative hypothesis could be:

i) mean yield of district-A is not same as the mean yield of district-B – leads to two tailed test i.e. $\mu_1 \neq \mu_2$.
ii) mean yield of district-A is < mean yield of district-B – leads to left tailed test i.e. $\mu_1 < \mu_2$.
iii) mean yield of district-A is > mean yield of district-B – leads to right tailed test i.e. $\mu_1 > \mu_2$.

Level of Significance: It is the percentage chance that null hypothesis is rejected though it is true. If the null hypothesis is true, the significance level is the probability that it will be rejected in error. This chance of committing error arises due to fluctuations in sampling. Popular levels of significance are 5%, and 1%.

Example

	Truth	
Verdict	***True***	***False***
True	No Error	Type II Error
False	Type I Error	No Error

5% Level of Significance: It means there is 5% chance that we reject null-hypothesis though it is true. Consider the above example. Say we rejected null hypothesis and concluded that the mean yield of district-A is not same as the mean yield of district-B at 5% level of significance on the basis of sample scores. It implies that there is 5% chance that mean yield of district-A is same as the mean yield of district-B in the population and we concluded wrongly that they are not same.

1% Level of Significance: There is 1% chance that we reject the null hypothesis, though it is true. Consider the above example. Say we rejected null hypothesis and concluded that the mean yield of district-A is not same as the mean yield of district-B at 1% level of significance on the basis of sample scores. It implies that there is 1% chance that mean yield of district-A is same as the mean yield of district-B in the population and we concluded wrongly that they are not same.

Testing of hypothesis - small sample tests

The aim of this section is to draw inferences about a population from a small sample.

1 Two Sample t-Test

Let μ_1, μ_2 are the mean outcomes in treatment group and control group populations and $\overline{x_1}$ and $\overline{x_2}$ are mean outcomes of random samples of sizes n_1 and n_2 drawn independently from the populations of treatment group and control group.

Assumptions:

i) Population from which samples are drawn is normal.

ii) The samples are drawn independently and at random.

iii) Population standard deviations (S.D.s) are equal

Constraints:

i) Common population S.D. is not known

Null Hypothesis: $H_0 : \mu_1 = \mu_2$

Outcome in treatment group is equal to outcome in control group.

Test statistic:

$$t = \frac{(\overline{x}_1 - \overline{x}_2) - (\mu_1 - \mu_2)}{s_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}},$$

follows t distribution with $(n_1 + n_2 - 2)$ degree of freedom.

Where, S_p is Pooled S.D.

$$s_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2},$$

$$s_1^{\ 2} = \frac{1}{(n_1 - 1)} \sum_{i=1}^{n_1} \left(x_{1i} - \overline{x_1}\right)^2$$

$s_2^{\ 2}$ may be computed using a similar formula.

Conclusion: If calculated t is greater than t table value for $(n_1 + n_2 - 2)$df at required level of significance, the null hypothesis is rejected. It is concluded that there is significant difference between two means with respect to character under consideration. Otherwise, null hypothesis is accepted.

Example: Principal Investigator (PI) of National Innovations in Climate Resilient Agriculture (NICRA) project wanted to see whether there is any difference in yield of maize crop between a village adopted by NICRA (where technologies proven to offer resilience against drought were demonstrated) and a neighbouring village in a drought year. A sample of 10 maize farmers were drawn at random from each village. The yields (in t/ha) obtained by the sampled farmers are as under.

NICRA village	3.6	3.7	3.3	4.5	4.4	3.9	2.9	3.2	3.5	4.1
Neighbouring village	2.2	2.6	1.8	3.4	2.8	2.3	3.6	1.7	2.7	2.9

The difference in yield between the villages may be attributed to NICRA interventions. Make a statement about the significance of the difference.

Solution:

i) sample sizes are n_1 = 10, n_2 = 10

ii) $H_0 : \mu_1 = \mu_2$

$H_1 : \mu_1 \neq \mu 2$

iii) Test Statistic

$\overline{x_1}$ = 3.71, $\overline{x_2}$ =2.6

s_1^2 = 0.387 s_2^2 = 0.27 S_p = 0.328

$$t = \frac{(3.71-2.6)-0}{0.328\sqrt{\frac{1}{10}+\frac{1}{10}}} = 4.33$$

Conclusion: t (Cal) = 4.33 is greater than t (table) value i.e. 2.88 at 1% level of significance. Hence null hypothesis is rejected and concluded that the difference is statistically significant. It can be inferred that NICRA interventions had positive impact and built resilience against drought.

2 Paired t-Test

When to use paired t-test:

The sample sizes should be equal and the two samples are not independent (sample observations are paired together). For example, difference in performance of a group of farmers before and after training may be tested using this test. Let μ_1, μ_2 are the performances before and after training. A random sample of size n is drawn from the group of farmers who undergone training. Let x_{i1} and x_{i2} are the pair of observations pertaining performance before and after training respectively on i^{th} (i=1, 2, ...n) sampled farmer.

Assumptions:

i) Population from which samples are drawn is normal.

ii) The paired sample is drawn at random.

iii) Population S.D.s are equal

Constraints:

i) Sizes of the samples are equal

ii) Common population S.D. is not known

Null Hypothesis: H_0 : $\mu_1 = \mu_2$

There is no difference in performance before and after training

Test statistic: $t = \frac{\bar{d}}{\sqrt{\frac{S_d^2}{n}}}$ follows t distribution with $(n - 1)$ degree of freedom.

where, $\bar{d} = \frac{1}{n}\sum_{i=1}^{n} d_i$ and $d_i = x_{i1} - x_{i2}$

$$S_d^2 = \frac{1}{n-1}\sum_{i=1}^{n}\left(d_i - \bar{d}\right)^2$$

Conclusion: If calculated t is greater than t table value for (n-1) df at required level of significance, the null hypothesis is rejected. Otherwise, null hypothesis is accepted.

Example: A paddy farmer found his field affected by a pest. He selected 15 hills at random and marked them. He recorded the number of insects per hill. He sprayed a chemical to control the insect. Two days after the spay, he again recorded the number of insects per hill. The number of insects per hill before after the spray are as under.

Hill No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Before Spray	52	46	49	58	41	38	44	35	36	43	31	55	46	47	50
After spray	12	18	14	9	8	15	11	14	10	8	12	5	13	4	8

Test whether the chemical was effective in controlling the pest?
Solution:

H_0: The chemical is not effective in controlling the pest and the reduction in insect count is due to fluctuations of sampling.

H_1: The chemical is effective in controlling the pest

Computation of Test Statistic: $\overline{d} = 34$ and $S_d^2 = 91.57$

$$t = \frac{34}{\sqrt{\frac{91.57}{15}}} = 13.76$$

Conclusion: t (tab) value for 14 degree of freedom at 5% level of significance is 2.14. Here we find that t (cal) is > t (tab). Hence, null hypothesis is rejected at 5% level of significance and it is concluded that the chemical is effective in controlling the pest.

Testing for impact of a programme on Adoption of Technology

Proportion: The proportion of individuals having a particular characteristic is the number of individuals possessing the characteristic divided by total number of individuals. Suppose we create a variable that equals 1 if the individual has the characteristic and 0 if not. The proportion of individuals with the characteristic is the mean of this variable because the sum of these 0s and 1s is the number of individuals with the characteristic.

Test of Significance for Difference of Proportions

Testing of the Null Hypothesis

H_0: $P_1 = P_2$ (the population proportions are equal)

against Alternative Hypothesis

H_1: $P_1 \neq P_2$ (the population proportions are not equal).

The test is performed by calculating z statistic and comparing its value to the percentiles of the standard normal distribution to obtain the observed significance level. If this probability value is sufficiently small, the null hypothesis is rejected.

$$Z = \frac{(\hat{P}_1 - \hat{P}_2) - 0}{\sqrt{\hat{P}(1-\hat{P})\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$ follows N(0,1)

Where $\hat{P}_1$ and $\hat{P}_2$ are the estimated proportions computed from samples of size n_1 and n_2, respectively.

$\hat{P}$ is the proportion of individuals having the characteristic when the two samples are pooled together.

$$\hat{P} = \frac{n_1\hat{P}_1 + n_2\hat{P}_2}{n_1 + n_2}$$

Example: A KVK claims that adoption of technology is more in the village adopted by them compared to neighbouring village. Independent random samples of size 40 has been drawn from each village. The estimated proportions (on the basis of samples) are 0.7 and 0.4 for the KVK adopted village and neighbouring village respectively. Please verify the claim of the KVK?

Solution:

H_0: $P_1 = P_2$ H_1: $P_1 \neq P_2$

$$\hat{P} = \frac{(40*0.7 + 40*0.4)}{40+40} = 0.55$$

$$Z = \frac{0.7 - 0.4}{\sqrt{0.55*(1-0.55)\left(\frac{1}{40} + \frac{1}{40}\right)}} = 2.70$$

Conclusion: Calculated Z (2.70) falls in the rejection region, as Z table value is 1.96 at 5% level of significance. Therefore, null hypothesis is rejected and the claim of KVK is admitted. It is further concluded that adoption of technology is more in the village adopted by the KVK compared to neighbouring village.

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IMPACT OF DEVELOPMENT INTERVENTIONS IN GOVERNMENT SCHEMES

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Development interventions are required for making Indian agriculture vibrant due to the low or absence of self-propelling capacity of majority of the farmers who are struggling in resource poor conditions. Hence governments at the Union and the State level have introduced and implemented appropriate schemes for the overall development of the agriculture and allied sectors. The government schemes are basically of two types- infrastructure and capital-intensive schemes and the other ones are the production and short term in nature. The following broad categories of government schemes promote agriculture and rural development:

- Agriculture & Allied Sectors' Development
    - Rural Development
- Forests, Environment & Climate Change Ministry
    - Other Ministries

The different types of agricultural Development Interventions include -

- *Land Development like Soil & Water Conservation*
- *Plantation of different species*
    - Scientific and integrated crop management such as nutrient (INM) and pest management (IPM)
    - Water efficiency measures such as micro irrigation
- *New technologies*
    - Seeds, other technologies
- *Marketing assistance*
    - MSP, FPOs, cold storages, other godowns etc.
- Startups etc.

Further, various rural development schemes that supplement and complement agriculture schemes are also introduced by the government -

- Employment generation; Asset creation (NRM etc.) under MGNREGA
- Livelihood activities in Aajeevika (NRLM)
- Watershed Development etc.

- MoEFCC

- National Afforestation Program
- National Action Programme for Combatting Desertification

Why Impact/Evaluation studies

Schemes implemented by the governments incur public money. Hence, assessing the role of interventions made as part of such schemes on the implications brought about is essential. Further, the focus and thrust of such schemes is on Problem solving and development focus. It is also done to assess the success and upscale/ replicate models / interventions.

How to do Impact Assessment

There are several ways to do impact of development intended schemes. Some of them are -

- Case studies
- Cross section studies

The specific methods employed include-

- Beneficiary interviews
- Focus Group Discussions
- Field surveys

Who will do the Impact studies

The qualified and the people with expertise in the area would be better suited for the job. Generally, it is advisable that those who are not having any stake during initiation, funding or implementation must be involved for impact assessment. Therefore, people who are Academicians, Development Agents, NGOs, Freelance personnel would be better suitable for impact assessment. Always it is better to avoid self-assessment.

What to study?

The impact study must focus on the following aspects

- Benefits
    - Livelihoods, Technology adoption, Rate of returns on Investment,Area development, Resource Status etc.
- Beneficiaries
    - Intended, unintended, gender, etc.
    - Direct beneficiaries
    - Spill over – Lateral and vertical

Some of the experiences of the author along with colleagues in Impact assessment are:

- RKVY
- SAIDP
- DAIDP

- Mainstreaming Biodiversity in Development schemes
- Environmental Impact Assessment of Tobacco Curing

Main Findings of EIA Study on Tobacco Curing

- Fuelwood used in Tobacco barns
- Improved barns
- Alternate energy
- Source of fuelwood etc.

Salient Findings of the Watershed Impact Assessment Study

- Water storage capacity in the water shed increased
- Groundwater increase : 23 – 35 %
- Cropping Intensity Rise: 3 – 23 %
- Crop Productivity Increased by 32-38 % in Cotton & by 18-29 % in Vegetables
- Milk Productivity increased by 13-32 % across the four watersheds studied

Framework of Impact Evaluation Study of NADP projects implemented during 2013-14

S. No.	Objectives	Indicators to be assessed	Sources of information	Tools and Techniques
1.	Project activities implemented as per the RKVY Guidelines	List of projects implemented by the agency with the implementation steps	Secondary data from line departments, Implementing agency	Discussion, Secondary data about their programme implementation
`2.	Value of the project	1. Type of the project 2. Project cost 3. Duration of the project 4. No. of beneficiaries 5. Impact of the project	Farmers and implementing agency	Focus group discussion and Interview schedule
3.	Socio economic profile of beneficiaries pre and post project	1. Working days 2. Yield 3. Income 4. Cropping intensity 5. Irrigation intensity 6. Ground water table 7. Crop diversification 8. Asset creation 9. Standard of living 10. Nutritional care	Farmers from 8 districts -Socio economic profile	Interview schedule, Participatory impact evaluation with the farmers
4.	Opinion of the farmers regarding the implementation of projects	 completely satisfied 1, very satisfied 2, satisfied 3, less satisfied 4, dissatisfied 5 With justification	Farmers from 8 districts - Opinion about the implemented projects – 2013 -14	Interview schedule, Participatory impact evaluation with the farmers
5.	Success stories and Good practices documentation	▪ Case studies / Success stories ▪ Good practices	Farmers and implementing agency	Case studies and Good practices

Source: Tata-Dhan Academy DHAN Foundation Madurai, 2017. RKVY Tamil Nadu Impact Evaluation

Examples of Project Outcome and Impact Assessment Indicators

Focus of the project Development Objective	*Stake holders in ARE Project*					
	Donor – World Bank	*Barrower-Ministry of Agriculture*	*Research or Extension Agency*	*Academic Institution*	*Private sector*	*Farmer or Producer Group*
Poverty reduction	X % increase in poor small holder's household real income	X % increase in poor small holder's household real income	X % increase in farm income	X % increase in farm income	Sales of crops increased by x %	Increase in number of meals with meal or fish
Productivity change[1]	X % increase in small holder crop production and farm income	X % increase in small holder crop production	X % of farmers have access to improved varieties	Number of staff with improved technical skills	Input sales increased x % by year x	Staple food yield increase
Institutional development [2]	Number of regions covered by good quality ARE services	Number of regions have decentralize d ARE services	Generation and transfer of good quality technologies to x% of farmers	Number of staff in collaborati ve ARE programme	X % of farmers have access to company inputs and/or services	Extension agents visit rural communiti es frequently
Market development	Farmers access to markets improved by x%	Farmers access to markets improved by x%	Demand of high-value commodity research increased	Change in farmers ability to market products	Number of productio n contracts with farmer groups	X% of higher price from vegetables
Capacity building	X% increase in farmer groups participatio n in decision making in the area	X% increase in autonomou s farmers groups' formation in the area	X% increase in participatory technology development	High level of participatio n among farmers	Number of contracts with farmer groups increased	X% increase in farmer groups membershi p
Environment al sustainability	X % of farmers adopting environ sound production practices	X % of farmers adopting environ sound production practices	X% increase in generation of environmental ly sound technologies	Number of trainings to extension staff in environ sound practices	X% of farmers trained in safe pesticide use	Reduction in pesticide application s or increase in land under no-till

Source: IBRD- World Bank, 2005

Conclusions

Impact assessment is thus a key aspect of any development intervention. That too when public funded schemes are implemented, it is imperative that the scheme funding agency and the implementing department has to get the implications studied on the beneficiaries, the impacted area and the resources etc. Several approaches have been discussed. Depending on the nature, time available and the resources meant for the purpose, such impact studies need to be carried out.

IMPACT ASSESSMENT OF KVK INTERVENTIONS

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Introduction

Out of total cultivated area of around 140.30 million hectares in India, only 60.86 million ha. is irrigated and the remaining 79.44 million ha. is rainfed. Rainfed crops account for 48 percent area under food crops and 68 percent of the area under non-food crops. Rainfed areas are generally endowed with fragile resource base and low productivity. Majority of the inhabitants are resource-poor and are obliged to eke out an existence in harsh biophysical and socio-economic environments. They are subjected to climate change through extreme weather events, decrease of water availability and decrease in agricultural productivity. The problem to be addressed is the limited access to and exchange of, information and knowledge related to agriculture and food security at local, national, and regional levels. The productivity improvements in rainfed areas shall be achieved through adoption of established technologies by farmers. This can be done by supporting efforts of researchers, extensionists and farmers working in rainfed areas through increased knowledge exchange and sharing (CRIDA, 2007 and 2009).

Adoption of Technologies

Adoption is, "the mental process an individual passes from first hearing about an innovation to final adoption" (Rogers, 1962). It is always an individual decision process. Information and learning are argued to be central to the adoption process. Among other factors, whether to adopt a technology or not depends on the profitability of the technology, farmer education/learning, and other observed and unobserved differences among farmers and across farming systems (Suri, 2009). Risk aversion discourages adoption, as uncertainty will always be greater for the new technology than for the old (Marra *et al.*, 2003). Risk is a major factor limiting the adoption of new innovations (Lindner *et al.*, 1982; Lindner, 1987; Tsur *et al.*, 1990; Leathers and Smale, 1992; and Feder and Umali, 1993). For a new technology to be successful, extension efforts and training /trailing of the technology need to be in place, and the needed inputs must be procured. Designing technologies that can be implemented by households with labor and land constraints, notable correlated with poorer households, is a continued need of extension programs (Jones, 2005). Extension, promotion and marketing programs by government workers and/or the private sector can be positively related to adoption (e.g. Marsh *et al.,* 2000; Llewellyn *et al.*, 2003). Reasons for non-adoption of dryland agricultural technologies were discussed at length and are: irregular and inadequate rains, inadequate finance, non-availability of inputs, lack of improved implements, high cost and complexity of certain practices and lack of guidance (Wasnik, 1988; Farooque, 1990). Age, farming experience were found to be non-significant; while education, annual income were positively significant with the adoption of package of improved agricultural practices of dryland farmers in the Bellary district of Karnataka (Padmaiah *et al.*, 1992). Farm size was positively significant with the adoption of recommended dryland agricultural technologies of dryland farmers in Aurangabad district of Maharashtra (Dakhore *et al*., 1993). \

Prologue about KVK, CRIDA

Krishi Vigyan Kendra (KVK) Rangareddy district was established in 1977. It is attached to the Central Research Institute for Dryland Agriculture (CRIDA) Hyderabad. The main objectives of KVK are:

- To transfer the latest agricultural technology to the practicing farmers, farmwomen, rural youth and field level extension functionaries through need based, skill-oriented training on the basis of work experience, following the principles of 'learning by doing' and 'teaching by doing'.
- To demonstrate the worth of improved farm technologies on farmer's fields through conducting Frontline Demonstrations (FLDs) on various mandatory crops of the district.
- To test and verify the technologies in the socio-economic conditions of the farmers through on-farm trials with a view to find out whether technologies suited to the micro-farming situation.
- To create awareness and popularizing improved farm technologies through Field Days, film shows, exhibitions, Farmers Days, study tours etc.
- To develop close functional linkages between various district / state level development departments and institutions, NGOs, credit organizations and rural people for quicker transfer of technology through operating collaborative programmes.

Study Results

The study was conducted in Mirzapur village of Pudur mandal of Rangareddy district of Telangana. This village is KVK adopted since June, 2011. A sample of 40 farmers was selected purposively for data collection. The data was collected using a pre-tested interview schedule from the farmers. Focus group discussion and interviews were conducted to elicit data from farmers.

a) **Socio-economic and Personal characteristics of Farmers:**

From the selected farmers' (n=40), 70 % of them are above the age of 40 and 65 % having land holdings below three acres; 55 % had no education; 62 % had less than 30 years farming experience; 42 % had annual income below Rs.25,000/- and 35 % have annual income ranging between Rs.25,000-40,000/-The main crops in the village are paddy, cotton, maize, sorghum, pigeon pea and vegetables.

b) **Sources of Farm Power:**

Source of Farm power	Percentage
Bullocks	**27.5**
Pump set or oil engine	25
power tiller	10
tractor	10
Others (Please specify)	0

c) **Livestock possession:**

Livestock Possession	Percentage
Cows	**25**
Buffaloes	12.5
Goats	12.5
Lamb	2.5
Poultry	5

d) **Mass media exposure:**

Mass Media Exposure	Percentage
Radio	7.5
Television	**72.5**
Newspaper	12.5
Agricultural books	2.5
Agricultural information material	0
Agricultural magazines	5

e) Extension contacts:

Extension contacts	Percentage
AEO	70
AO	70
Scientists (KVK)	**82.5**
Veterinary Scientists	30
Others	2.5

f) Adoption of technologies/Livelihood Interventions:

Crops/ Technology	S. No.	Proposed KVK Technologies/ Interventions	Adoption		Reasons for Adoption	Constraints in Adoption
			n	%		
Sorghum	1.	Shoot fly management in Sorghum	30	75	Following early sowings and increased seed rate along with soil application of Carbofuron @ sowing time. Ease of operation.	--
Pigeon pea	2.	Pigeon pea wilt tolerant variety PRG-158	36	90	Wilt tolerant. Good yields, fetching good market price.	--
	3.	IPM in Pigeon pea	26	65	Using neem oil, bird perches and chemicals.	Pheromone traps and NPV not readily available.
Maize	4.	Production technology in Maize	36	90	Following spacing, fertilizer & pesticide recommendations correctly now. Previously used excess fertilizer doses.	--
	5.	Stem borer management in Maize	39	97.5	Scrupulously following Monocrotophos spray @1.6ml/lt. at 10-12 DAS.	--
	6.	Zero till Maize after rice	10	25	--	Weed problem and less yields override cost and time savings.

Cotton	7.	Spacing and fertilizer management in Cotton	39	97.5	Following recommended spacing's and fertilizer doses.	--
	8.	Management of sucking pests in Cotton (Stem application with Monocrotophos and Verticillium spray)	35	87.5	Convinced of the reduced use of Monocrotophos along with less labour requirement.	--
Tomato	9.	Tomato nursery raising in pro-trays & shade net (income from it)	36	90	Cost saving by reducing the seed rate for production of seedlings per acre. No weed problem. Shade nets protect from direct heat and germination will be good.	--
	10.	Drip Irrigation system	37	92.5	Savings in water. Less problem of weeds.	--
Fodder	11.	Demonstration of perennial fodder hybrid Bajra Napier CO-4	38	95	Lustrous green growth of fodder. Higher milk yields.	--
	12.	Perennial fodder hybrid Bajra Napier APBN-1	13	32.5	--	Leaves are spiny and coarse in texture.

Discussion

Technologies/Interventions of KVK are as such very good and proven. During the period of KVK operation (2011-14), more than 80% adoption is recorded for almost all technologies like farm machinery, varietal evaluation, IPM, home science, fodder and feed management, micro irrigation using drip and sprinklers and NRM activities. However, with withdrawal of KVK some of the technologies/interventions becomes out of reach (impractical), particularly those that requires capital on the part of farmer. Eg: machinery, mulch material and NRM works.

It means to say that for continuous adoption, additional working mechanisms need to be in place like extend hand holding for few more years, form groups for ease of operation and develop confidence of farmers so that, they can continue even when projects from outside terminate. Farmers should be advised to realize that returns are more than investments in the long run especially in NRM activities in drylands.

g) Impact of KVK Interventions on the Productivity of major Irrigated crops in Yenkepally:

S. No.	Crops	Yield Before (q/acre)	Yield After (q/acre)	% change
Kharif				
1.	Maize	6.5	10.2	57
2.	Cotton	4.3	6.7	56
3.	Sorghum	5	7	40
4.	Paddy	16	22	38
5.	Red gram	2	3.1	55
6.	Tomato	4	6.2	55
Rabi				
1.	Maize	3	4	33
2.	Paddy	19.7	22.3	13
3.	Tomato	6	8	33

From the above table, significant productivity increase was observed especially in case of maize, cotton, red gram and tomato in major irrigated crops in Kharif.

h) Impact of KVK Interventions on the Productivity of major Rainfed crops in Yenkepally:

S. No.	Crops	Yield Before (q/acre)	Yield After (q/acre)	% change
Kharif				
1.	Maize	7	11	57
2.	Cotton	5	7	40
3.	Paddy	18.3	25.5	39
Rabi				
1.	Tomato	8	10	25

From the above table, significant productivity increase was observed especially in case of maize, cotton and paddy in major rainfed crops in Kharif.

i) Knowledge Gap Analysis of Adopted and Non-adopted farmers as a result of KVK Interventions:

Statistic/ Parameter	Knowledge score of Adopters	Knowledge score of non-adopters	Difference in Knowledge scores
Mean	25.1^{B}	18.1^{A}	7
Range	13 to 33	2 to 33	

^{AB} vary significantly at 1% level of significance

(p value=0.000151)

From the above table, there is a significant difference in knowledge score of 7 between adopters and non-adopters.

j) Knowledge levels of Adopted and non-adopted farmers as a result of KVK Interventions:

S. No.	Level of Knowledge	Adopted farmers		Non-adopted farmers		Knowledge gap (%)
1.	High (23-33)	29	72.5	14	35	37.5
2.	Medium (12-22)	11	27.5	15	37.5	-10
3.	Low (0-11)	0	0	11	27.5	-27.5
	Total	**40**	**100**	**40**	**100**	

From the above table, high level of knowledge exists among majority of adopted farmers, while, medium level of knowledge is high among non-adopted farmers.

k) Income levels of farmwomen:

S. No.	Major Activity	Income (Rs.) Approximation Basis	
		Before	**After**
1.	Tailoring and Zardosi work	100	400
2.	Preparation of Phenyle	100	400
3.	Baking products	100	300
4.	Preparation of iron rich recipes	50	200

Most of the activities were done by the women for themselves and their family. But not as a marketing venture. On an average, they could save three to four times the money, which they normally would have expended in the absence of the activity.

Conclusion

- Farmers' Knowledge about dryland technologies is very good. But needs to be translated to adoption, which requires more concerted efforts in establishing mechanisms and traits like ready availability, ease of use, less cost, less labour and time consuming etc. of different technologies and its components.
- The challenge is to take the technologies from Awareness-Knowledge stage to Practice-Adoption stage.
- The feasibility vis-à-vis workability of technologies is decided by farmers at trial stage itself (Awareness-Interest-Evaluation-Trial-Adoption stages).
- Row ratios, intercrops, spacing, fertilizer and chemical recommendations are by far, easily and readily adopted by farmers.

- Any technology/components of technology buying, owning and using (adopting) remain a bottleneck (far and distant) to majority of dryland farmers.
- Good crop varieties almost always show highest adoption by farmers with little dissemination efforts required by extension.
- Adopters had better knowledge and adoption rates over non-adopters in both the adopted villages.
- Productivity of farmers increased several fold with KVK interventions.
- Income levels of farm women increased three to four times based on the enterprise after adopting KVK interventions.

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IMPACT ASSESSMENT OF USE OF DIGITAL TOOLS IN EXTENSION: CASE STUDIES -REVIEW

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Introduction

In developing countries like India, productivity growth in small-farm agriculture can serve as an important driver of economic development and poverty reduction ((Mellor *et al*., 2017) and (Ogutu SO *et al*., 2019)). However, smallholder farmers typically face many challenges, such as unpredictable weather conditions, market risks, and limited access to information, technologies, and financial services. These and other constraints result in low productivity and low rates of market participation (Key N *et al*., 2000). Hence, a key policy question for promoting rural development and poverty reduction is how the main information and market access constraints that small holder farmers face can be overcome.

In most developing countries, agricultural extension services are the dominant method of public-sector support towards knowledge diffusion and innovation in the small-farm sector (Takahashi K *et al*., 2020). Traditionally, extension agents have either tried to educate farmers directly about best practices or have worked with selected "model farmers" who are then expected to act as information multipliers (Taylor M *et al*., 2018). However, the effectiveness of traditional extension approaches has been limited, either because of too little funding and thus low outreach or information that is not sufficiently tailored to farmers' needs (Pallavi Rajkhowa *et al*., 2021).

The application of Information and Communication Technology (ICT) across different sectors of the global economy has become a game changer in boosting work efficiency and productivity. The agriculture sector in the global economy is one of the industries experiencing tremendous ICT application in all spheres of its operations. Daum (2020) observed that in recent years, ICTs had become one of the main driving tools used by farmers to manage the essential factors of production (land, labour, capital, and soil) in agriculture. ICT applications have the potential to identify and find solutions to some of the numerous problems faced in the field of agriculture, which includes prolonged droughts, pest and disease outbreaks, seasonality and spatial dispersion of farming; high transaction costs and information asymmetry (Anh *et al*., 2019)

Wolfert *et al.*, (2017) observed that technological advancement in the area of digital platforms, such as e-commerce, agro-advisory apps, big data, computational power, and satellite systems like remote sensing, among others, quicken communication and information sharing among farmers in recent years. Mobile phones that have internet connectivity (smartphones) are the most widely used ICT devices across the globe (O'Dea, 2020). Research published by Statista (2020), showed that the number of smartphone users around the world were 3.2 billion in 2019, and forecasted that this figure could reach 3.8 billion by 2021. The research further indicated that developing countries have the highest share of smartphone users worldwide (O'Dea, 2020). The pace at which ICT application is growing in every sector of the world has triggered the development of different ICT applications in the agriculture sector to aid the rapid access to information by farmers, extension services, and other players within the sector (Daniel Ayisi Nyarko *et al., (*2021), but empirical evidence of actual impacts is scarce. One of the critical factors that contribute to favourable digital extension policies is better impact assessment and documentation, which is at present lacking.

Therefore, there is need to assess the impact of use of information and communication technologies (ICT) among agricultural extension workers and its implications on extension delivery.

Impact Assessment

Impact assessment is the analysis of the significant change that has occurred due to an action or series of actions (intervention). This involves what has changed, for whom, how vital the change was, how long the change will last and in what ways our actions have contributed

to that change. It is important to assess the impact of the intervention to determine the success of the intervention, how it has impacted the beneficiaries and the local community, and also to use the findings of the assessment for recommending changes in the policies. It also helps us to be accountable to the funding agencies or institutions for which we are working. Impact assessment tries to establish a causal relationship between inputs and changes in terms of magnitude or scale or both. Based on effect, the impact of any intervention can be (Rogers 1995, Airaghiet.al., 1999, Kelley*et.al.,* 2008). 1.Positive, negative. 2.Direct, indirect. 3.Primary, secondary. 4.Intended, or Unintended. 5.Short/Medium/Long term. Generally, the flow or sequence of a project/ programme/ scheme would be as follows;

Further, considering the measures of efficiency, consistency and effectiveness, the same can be illustrated as given in Figure1.

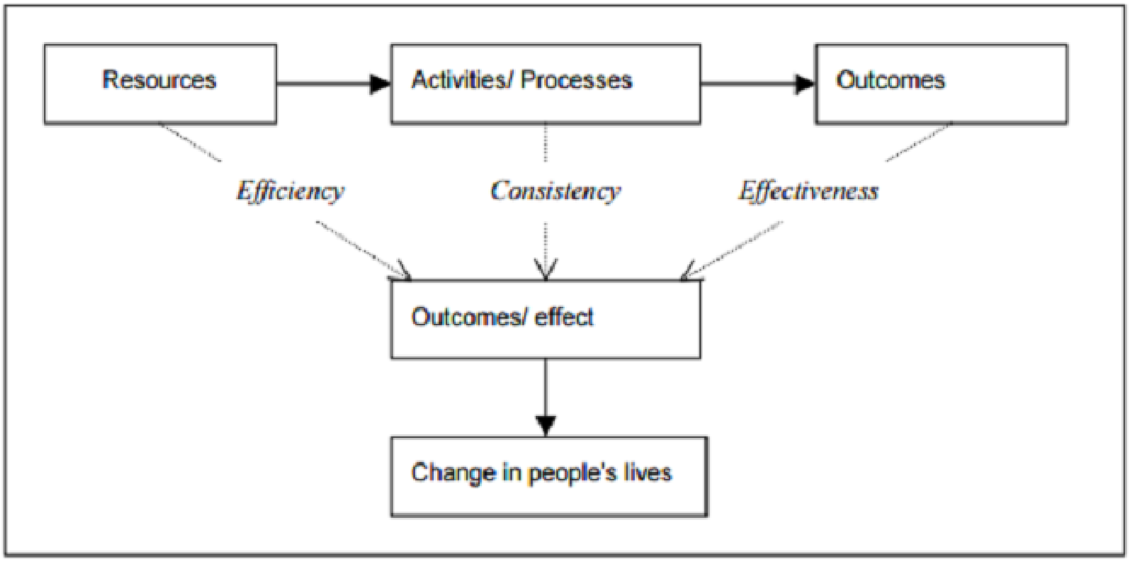

Figure 1: The Research and Development impact continuum. (Source: Roche, 1999)

Some of the reasons for carrying out impact assessment, which also a sort of evaluation of projects or programmes is (Suvedi and Stoep, 2016):

- Should the government and donors continue to fund extension programs?
- Are the extension programs effective?
- How would you improve or terminate ineffective extension programs?
- What new programs should be implemented to meet the needs of farmers, or to address changes of the rural agricultural clients you intend to serve?

Digital Impact Assessments

Now a days through ICTs people can obtain the latest up-to-date information, learn and practice sustainable farming. All these studies on different ICT applications specifies the unique ways of it in out reaching larger farmer masses. The five main trends that have been the key drivers for the use of ICT in agriculture, particularly for poor producers: low-cost and pervasive connectivity, adaptable and more affordable tools, advances in data storage and exchange, innovative business models and partnerships and the democratization of information, including the open access movement and social media. These drivers are expected to continue shaping the prospects for using ICT effectively in developing country agriculture. Thus, ICT has emerged as a core driver of the modern knowledge-based economy promoting socio-economic development of the country. Thus, the present study is an effort to understand the role played by the ICTs in improving the lives of the farmers.

ICTs have long been recognized as key enablers for bridging the digital divide and achieving the three dimensions of sustainable development: economic growth, environmental balance and social inclusion. . However, in order to exploit the latent potential of ICT devices and digital services effectively, the characteristics of the driving forces behind new technologies have to be understood. Digital technology can also be used to deliver e-agriculture, a more streamlined agricultural production system often called “precision agriculture”. e-agriculture has the potential to contribute to a more economically, environmentally and socially sustainable agriculture that meets the agricultural goals of a country or a region more effectively in the following areas (detailed in Fig. 2):

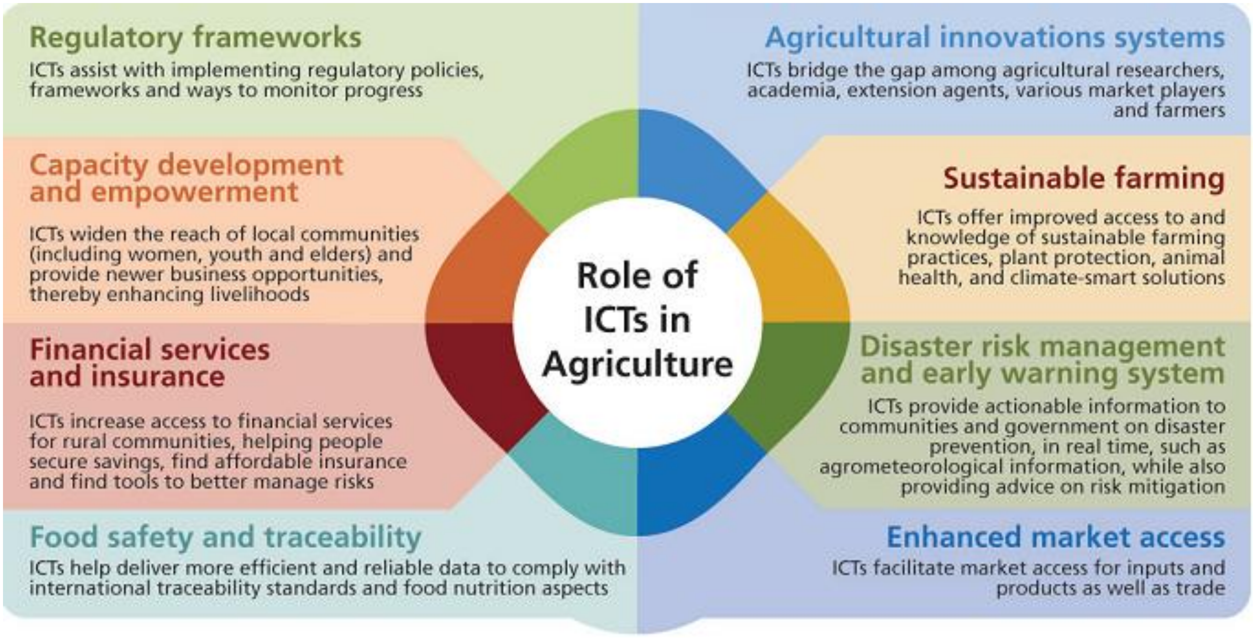

Figure 2: Role of ICTs in agriculture (Source ITU and FAO 2016)

Periodical studies need to be undertaken to evaluate the ICT initiatives undertaken for further expansion. This paper in detail analyses case studies, which teaches several unique ways in which ICTs can help. Current needs of ICT are also analysed and recommendations to promote them extensively amongst the farmers is also envisaged. This current study revealed that ICT initiatives are meeting the selected portions of the population and they have to be popularized to meet the large sections of the community.

This paper explores why Measuring the impacts of information and communication technology (ICT) is important for development – and it is statistically challenging. Measuring impacts in any field is difficult, but for ICT there are added complications because of its diversity and rapidly changing nature.

1. Impact areas Identified

A realistic international performance evaluation and benchmarking (both qualitative and quantitative), through comparable statistical indicators and research results, should be developed to follow up the implementation of the objectives, goals and targets in the Plan of Action, taking into account different national circumstances.” (ITU, 2005)

There are significant impacts of ICT. (ITU 2006). Impacts of ICT statistically is far from simple, for several reasons:

- ➢ There are a number of different ICTs, with different impacts in different contexts and countries. They include goods, such as mobile phone handsets, and services, such as mobile telecommunications services, which change rapidly over time.
- ➢ Many ICTs are general-purpose technologies, which facilitate change and thereby have indirect impacts.
- ➢ It is difficult to determine what is meant by “impact”. For example, a model proposed by OECD for ICT impacts (Fig.3) highlights the diversity of impacts, in terms of intensity, directness, scope, stage, timeframe and characterization (economic, social or environmental, positive or negative, intended or unintended, subjective or objective).
- ➢ Determining causality is difficult. There may be a demonstrable relationship and a positive correlation between dependent and independent variables. However, such a relationship cannot readily be proven to be causal.

As per, OECD, 2007 the impacts components of the conceptual model as follows:

- ✓ Impacts of ICT access and use on individuals, organizations, the economy, society and environment;
- ✓ Impacts of ICT production and trade on ICT producers, the economy, society and environment.
- ✓ Impacts of use and production of content (in particular, electronic or digital content, which only exists because of ICT) on the economy, society and environment;
- ✓ Influence of other factors on ICT impacts, for example, skills, innovation, government policy and regulation existing level of ICT infrastructure

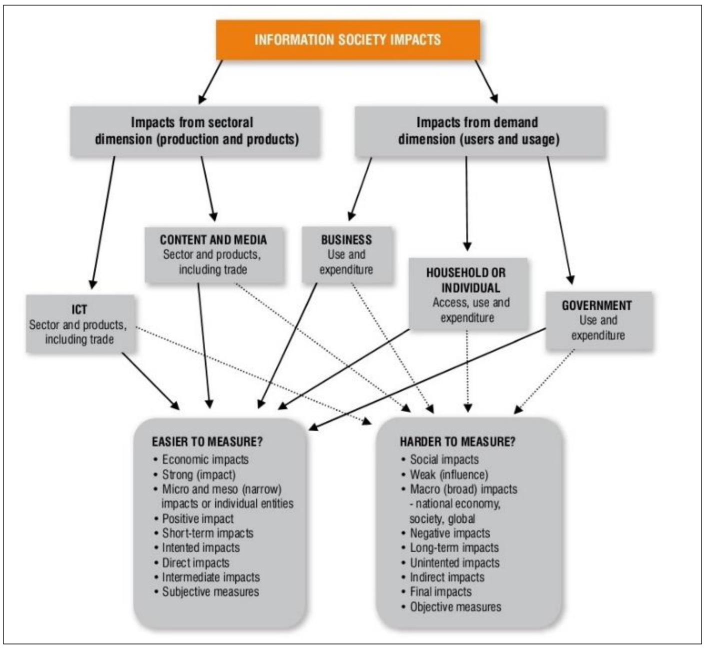

Figure 3: Information society impacts measurement model (Source: OECD, 2007.)

Heeks and Molla's proposed value chain model as a basis for impact assessments of digital extension projects (Heeks and Molla, 2009) and it is built on a standard input-process-output model to create a sequence of linked resources and processes. In the adapted framework, the components, input, process and output have been substituted by inception, implementation and post-implementation, which are the key stages in the project development. The value chain is divided into four main targets for assessment as shown in Fig. 4. Till date most of the impact assessment studies focused on any or all of these components.

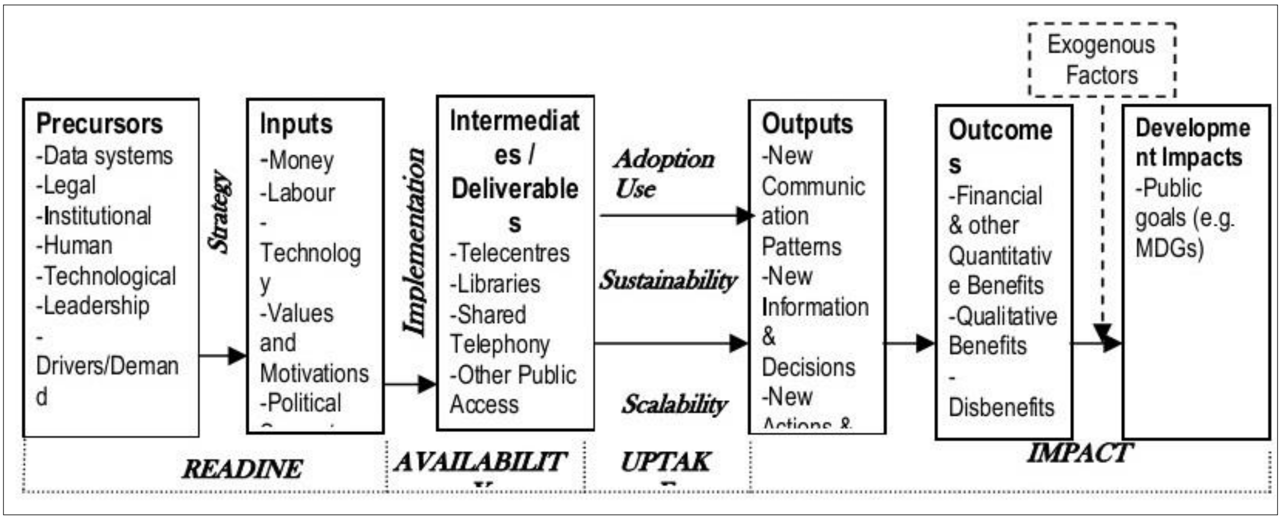

Figure 4: Value Chain model for Impact Assessment of Digital Extension Project (Source: Heeks and Molla, 2009)

Readiness: "e-readiness" assessment typically measures the systemic prerequisites for any ICT4D initiative e.g. presence of ICT infrastructure, ICT skills, ICT policies, and so on. One could also assess the strategy that turns these precursors into project specific inputs, and the presence/absence of those inputs.

Availability: implementation of the digital extension project turns the inputs into a set of tangible ICT deliverables; one can assess the presence and availability of these intermediate resources.

Uptake: assessment typically measures the extent to which the project's digital extension project deliverables are being used by its target population. Broader assessment could look at the sustainability of this use over time, and at the potential or actuality of scaling-up.

Impact: as the name suggests, only this focus actually assesses the impact of the project and we can divide it into three sub-elements:

Outputs: the micro-level behavioural changes associated with the digital extension project.

Outcomes: the specific costs and benefits associated with the digital extension project.

Development Impacts: the contribution of the digital extension project to broader development goals.

To some extent – and particularly in relation to outputs, outcomes, and development impacts – as you move from left to right along the value chain, assessment becomes more difficult, more costly but also more valuable. That move also represents something of a chronology. In assessing different aspects of the ICT4D value chain has changed over time, with the strong diffusion of ICT4D projects now creating most particular interest in assessment of impacts, as opposed to uptake, availability or readiness

2 Impact Assessment Frame Works

Assessment frameworks relating to digital extension projects impacts often include (Heeks and Molla, 2009) cost-benefit analysis, assessment of the impact of ICT on livelihoods, Controlled Experiments, Information Economics, Econometric model.

2.1. Cost-Benefit Analysis (CBA)

Identifies and quantifies the costs and benefits of Digital Extension projects and offers a logical and consistent framework of data analysis that facilitates assessment, decision-making and cross-project comparison. By making explicit link between inputs and outcomes including assumptions, it adds rigour to impact evaluation. CBA can be used to conduct ex-post financial evaluation of implemented projects and/or ex-ante evaluation of alternative investments. Its basic tenet (especially in the context of ex-post evaluation) is to assess the financial sustainability and cost-effectiveness of Digital Extension projects. The CBA framework uses traditional financial analysis and summary tools such as net present value, discounted cash flow or breakeven point to demonstrate the worth of Digital Extension projects once they are implemented. It is both a decision making (such as continuity, scalability) and communication tool (Fig.5)

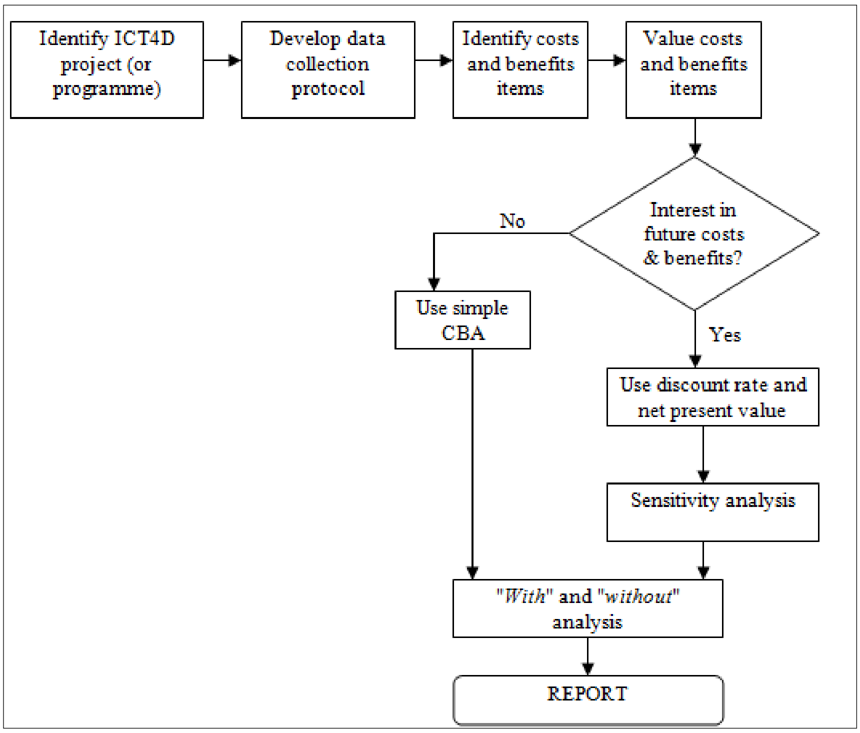

Figure 5: Summarises the generic process of a post-hoc cost-benefit analysis (Source: Heeks and Molla, 2009)

2.2 Livelihoods Framework

Strongly rooted in development studies, and recognized by extension researchers, the livelihoods framework provides an all-embracing framework for assessing the impact of digital extension on individuals and communities: context, assets, institutions, strategies and outcomes. The livelihoods framework (often known as the sustainable livelihoods/SL framework) developed from the pro-poor and participatory ideologies arising within the development field in the 1980s and 1990s. Its main argument has been that lives of the poor must be understood as the poor themselves understand their own lives as a complex of interacting factors (Figure 6)

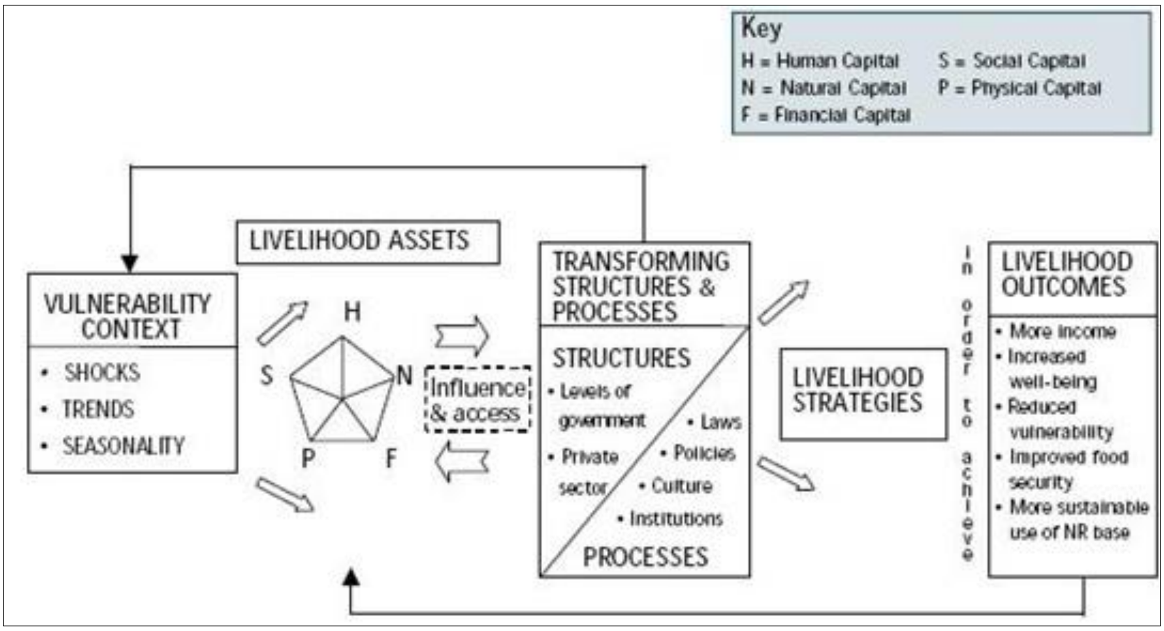

Figure 6: Livelihoods Framework (Source: Heeks and Molla, 2009)

2.3. Controlled Experiments

Controlled experiments are able to establish causality by having all the independent variables controlled. Therefore, the experimenter can alter a condition and observe the effect. In general, digital extension experiments cannot be controlled to the degree necessary to determine a 'cause and effect' relationship. However, where the conditions are limited, a controlled experiment may be possible.

2.4. Information Economics

Provides a firm foundation for analysis of the business (commerce/trade) related impacts of digital technologies. It covers the impact of digital technologies on information failures commonly found in developing countries and the related characteristics that make commerce slow, costly, risky and intermediated, and make markets and trade relatively slow to develop. Overall, it is a very useful approach where business isinvolved, though easier to apply if focused just on one business sector. Information economics takes an information-centric approach to assessment of digital systems, rooted in the information-oriented work of economists such as Stiglitz (1988). This sees development activity in terms of transactions, some interchange of goods or services and it sees information as required to support the decisions and actions integral to all transactions.

Key issues in the application of the impact assessment under this framework include:

Information Failures: which of these are addressed?

Other Characteristics: are process, structural and development characteristics also onsidered?

Specificity: is assessment narrowed to a particular technology and/or a particular sectoral supply chain?

Price: price is a key item of information in many transactions, aggregating other information (such as production and coordination costs, supply and demand). Comparing price levels and price fluctuations before and after ICT adoption can be a valuable impact indicator.

Transaction Scope: to what extent does the impact assessment cover the informational aspects of all three stages to a transaction?

2.5. Econometric Model

The econometric model attempts to measure the influence of different variables on various dimensions of extension service innovation due to digital technologies. Impacts of product and process innovation can be gathered on five main dimensions.

- Impact on productivity and extension costs.
- Service expansion
- Service Quality
- Skilled activities.

Conclusion

Impact assessment or evaluation is a logical consequence of programme or project implementation. The indicators and the method of evaluations mainly depend on the donors and the researchers‟ requirements besides the basis premises/ intensions of the project. Although several methods and instruments are available for assessment the cost, simplicity, and timeliness are important for choosing the appropriate ones. In any case, the assessment of the impact of digital extension interventions/project should be based on the continuous interaction between technical and socioeconomic processes. And extension organizations should keep evolving the new impact assessment approaches to suit to specific needs of digital extension needs.

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SOCIAL IMPACT OF WATERSHED PROGRAMS

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Watershed

A watershed is the area that drains to a common outlet. It is the basic building block for land and water planning. A watershed is an area that supplies water by surface or subsurface flow to a given drainage system or body of water, be it a stream, river, wetland, lake, or ocean (World Bank 2001). The characteristics of the water flow and its relationship to the watershed are a product of interactions between land and water (geology, slope, rainfall pattern, land use, soils, and vegetation) and its use and management.

Watershed Management

Watershed Management implies the proper use of all natural resources viz. land, water, vegetation and animals for optimum production with minimum hazard to the resources. It is the process of **implementing land use practices and water management practices** to protect and improve the quality of the water and other natural resources within a watershed.

Objectives of Watershed Development Programmes (WDPs)

Watershed development aims to balance the conservation, regeneration and use by humans of land and water resources within a watershed. Common benefits from successful watershed development projects include improved agricultural yields and increased access to drinking water. The overall attributes of the watershed development approach, by and large, are three-fold, viz. promoting economic development of the rural area, employment generation, and restoring ecological balance. However, the multiple objectives include:

- **Environmental-** For protecting vegetative cover throughout the year, to create ecological balance in the watershed area, protecting fertile top soil, utilizing the land based on its capabilities, in situ conservation of rain water, increasing ground water recharge, etc.
- **Economic-** It draws attention for increase in cropping intensity through inter and sequence cropping, maximizing farm income through agricultural related activities such as dairy, poultry, sheep and goat farming, improved and sustained livelihood status of the watershed community with special emphasis on the poor and women, etc.

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- **Institutional-**It includes formation of watershed committees and self-help- groups, establishing sustainable community organization, etc.
- **Social-**It includes alleviation of poverty, awareness generation, improving skills of the local community, capacity building activities, women's participation in decision-making process, empowerment of the community, etc.
- **Equity-**To develop equitable distribution of the benefits of land and water resources development and the consequent biomass production, involvement of village communities in participatory planning, implementation, social and environmental arrangement, maintenance of assets and to operate in a more socially inclusive manner.

Components of Watershed Development Programme

The components of watershed development programme would include;

- Soil and land management
- Water management
- Crop management
- Afforestation
- Pasture or fodder development
- Livestock management
- Rural energy management
- Other farm and non-farm activities and
- Development of community skills and resources.

All these components are interdependent and interactive.

Integrated Watershed Management

Integrated Watershed Management is the process of managing human activities and natural resources on a watershed basis considering social, economic and environmental factors to manage watershed resources sustainably (Conservation Ontario, 2010).

I. Social Impacts of Watershed programs

1. Reduction in workload

Rainwater gets harvested which helps in the retention of moisture in the soil. Increase in ground water and surface water helps for providing drinking as well as irrigation water and reduces the time to fetch drinking water. Soil and water quality and quantity, improve the availability of fodder and fuel wood also increases. As soil and water quality and quantity improve the availability of fodder and fuel wood also increases. Further, for women who are primarily assigned to fetch drinking water and water for all other household activities, watershed development programmes have been very instrumental in reducing work load.

Watershed programme resulted positively in reducing the workload of women in terms of fetching drinking water, collecting fuel wood and fodder for livestock by about 1-2 hours per day.

Major impacts were seen in the reduction of drudgery of women, as reflected in a comparative study between the daily diaries of women recorded in March 1996 and in March 2001. This revealed that, by March 2001: a) Women had more time (2 hour) to sleep at night and also to take rest (0.5 to 1hr) during daytime. They reported that their health had remarkably improved. b) The time taken to go to the forest had been reduced by 3½ hour in the mornings and by 1 hour in the evenings. c) Women had time for themselves and for their children between 12.30pm to 14.30pm. d) The drudgery involved in fuel-wood and fodder collection had been reduced, in terms of distance travelled, seasonality, time consumed and weight carried (Premsingh 2011).

2. Health, Hygiene, Vitality & Food Security of Women

In the opinion of the women, incidence of seasonal diseases has not only decreased between 1996 and 2001 but the number of days lost due to these diseases has also declined. Earlier they used to use home remedies and never sought medical aid. Thus, it could take two to eight weeks to cure a disease, which severely weakened the women. Due to greater awareness, the women now take medicine and even visit a doctor in time of need. They confirmed that seasonal diseases are now cured within a week. This awareness has shortened the ailment period and this, in turn, has helped women to maintain their health and vitality. The frequency of illness previously was mainly attributable to external hardship and internal weakness. The neatness and the hygiene of the children have also remarkably improved. The project constructed one toilet in this village in 1998 for demonstration purposes. Since then, nine additional toilets had been constructed by the villagers on their own initiative by 2001(Sitling 2007).

Raj and Jana (2020) reported that, before the project in Babuisol, 70.67 per cent of women went to the quack doctor for health problems but now it becomes 30.67 per cent. Now about 40.00 per cent of women go to govt. hospital for treatment. In Kuldiha also 57.33 per cent of women went to the quack doctor for treatment before the project which now became 33.33 per cent after the project. Now 40.00 per cent and 26.67 per cent of women go to govt. hospital and private nursing homes for their treatment.

3. Decreased Drop-out Rates by Girl Children from School

Normally a girl child in this village used to quit school after Class V to help her mother with household chores, while her mother walked to remote forest areas to procure fodder and fuel-wood. Since 1996 the time spent collecting fuel and fodder has decreased. This reduction in the workloads of the mothers and their increase in awareness is reflected in rise in attendance by girl children (vis-à-vis the boys) in Classes VI, VII and VIII standard over the last 9 years (Sitling, 2007).

4. Education and Social Status

Sreedevi *et al.,* (2007) revealed that, the right education rested more with men and the results to tilt education in favor of women will need longer time. In Kothapally the education of boys and girls is distinctively same as no child labour exists in this village. However, in Powerguda, women are aware now about educating their daughters. Interestingly, female literacy (52.00%) is higher than male literacy (48.00%). The social status of women in all the three study watersheds was better than the normal watershed village. However, amongst the three watersheds Janampeth women enjoyed higher social status in the society than the women in Kothapally and Powerguda.

5. Debt reduction position

Reduction of debt has many social and economic implications. This can help in reducing poverty and improving livelihood. The crop loss after huge investment in agriculture makes the farmers dependent on moneylenders and intermediaries. Many studies on farmer's indebtedness have reported that the farmers are victims of money lending. They fall under huge debt trap after investing large chunk of money in fertilizer, hybrid seed, cultivation operations, etc. without protective irrigation facilities. In such scenario, WDPs have helped a lot in providing irrigation facilities for better agricultural operation. WDPs have helped improving land use pattern, cropping pattern and agricultural productivity, livestock rearing, etc. The positive changes in agriculture, horticulture and livestock production have helped better income generation and debt reduction (Premsingh, 2011).

6. Involvement of Community Based Organizations (CBOs) and People's Participation

In watershed development programme it is essential that not only the Private Property Resources but also the Common Property Resources are developed, managed and maintained with active involvement of the local community. For this to happen, it is highly important that every stakeholder in the watershed accepts and implements the recommended management plan and is very much involved in the planning, implementation and maintenance phases of the project (Sharda *et al.,* 2008).

To increase participation, several groups like user groups, self-help groups, common interest groups, watershed committee, watershed association, etc. are formed. Due representation is given to all castes. Activities are planned and implemented with the help of these groups and these groups takes care of the maintenance and sustainability of the activities. These groups need to be formed carefully and trained well so that the assets created and benefits accrued are sustainable. For gaining higher benefits from the watershed related activities, greater involvement of the beneficiaries would be the important factor. Watershed programme led to in few instances of women being elected as Gram Panchayat President.

7. Employment generation and reduced migration

Employment generation in agriculture is one of the major concerned for the rural population in order to solve the problem of youth migration from rural area to urban area. Some agricultural crops, viz, paddy, sugarcane, vegetables and cotton require more human labour compared to most of cereals, pulses and oilseed crops. Human labour in agriculture used for preparation of land, sowing, transplantation, weeding, harvesting, threshing and transportation. Human labour is also needed for the performance of post-harvest management operations. A labour requirement in traditional crops is low. Therefore, it was hypothesized that there will be no change in employment generation until there is major shift in cropping pattern and technology with creation of water potential for irrigation after implementation of the project, there will be intensification and diversification of agricultural opportunities of on-farm employment will be increased.

Watershed project creates employment generation. Two kinds of employment opportunities, i .e., casual and regular were generated through implementation of various soil conservation and related works/activities under watershed project. Casual labor employment was created during the implementation of works such as bunding, leveling, check dams, ponds/ tanks, crop demonstration, plantations, etc. Due to diversified land use system, regular employment from horticulture, plantations, crops, etc., is also generated. During the time of field survey, the households revealed that migration to other places such as Ratnagiri, Goa, and Karwar, in search of livelihood has come down. 28.00 per cent of households reported decline in migration (Ujjainimath, 2015).

8. Social audit

The exercise of social audit seems all the more important when the stakes are high both in terms of investment and benefit. It also helps in making the program transparent. Social audit is conducted jointly by the government and the people, especially by those people who are affected by, or are the intended beneficiaries of, the scheme being audited.

The scope of social audit:

- A social audit is conducted over the life span of a scheme or programme, and not just in one go or at one stage

- It audits the process, the outputs and the outcome
- It audits planning, implementation, monitoring and evaluation

Social Audit provides an assessment of the impact of organizations non-financial objectives through systematic and regular monitoring, based on the views of its stakeholders. The foremost principle of Social Audit is to achieve continuously improved performances in relation to the chosen social objectives.

9. Women Rights and Gender Equity

In terms of rights, the results revealed that Janampeth ranked on top for property rights where women held the property rights along with men. In Kothapally and Powerguda the property rights were with the men except in the exceptional and circumstantial cases where women headed households due to death of male member. The nature and the extent of collective action provided different exposure for the members. In Janampeth the commercial nature of the collective activities resulted in control of family financial resources by women. In Kothapally as well as in Powerguda although women family members earned the money the control of family financial resources rested with men. In Kothapally women, group activities provided employment to women members mainly because of the type of activity undertaken. In Powerguda and Janampeth the collective action of Women created employment opportunities for women as well as men (Sreedevi et al., 2007).

10. Consumption pattern

As the income of a family increases, the consumption expenditure also increases, there is, thus a direct relationship between family income and consumption. There was about 10.00 per cent increase in per capita consumption expenditure after implementation of the project. The per capita consumption expenditure was estimated at Rs. 9936/annum under after implementation of the project in comparison to Rs. 9057 / annum on an average situation before implementation of the project. The increase per capita expenditure was mainly on account of higher spending on education, healthcare, clothing, beverage and miscellaneous items (Thakur *et al.*, 2014).

II. Technological impact of Watershed Programmes

1. Increase in ground water level

Increase in ground water table in watershed areas is one of the important measurable indicators of successful watershed programme. Various factors are accountable for increase in ground water. The water harvesting structures play a key role by storing water and allow sufficient time for water to percolate into the ground. Land development activities such as contour bunding, land levelling and cultivation practices also contribute towards accumulation of ground water. The increased water levels also render some respite in the drinking water situation in the project villages.

2. Increase in surface water and stream flow

Increase in surface water or stream flow is another indicator that can help establishing positive impact of watershed development programmes on physical factors.

3. Soil erosion reduction

Influence of soil conservation measures and vegetation cover on erosion, Runoff and Nutrient loss. Rainwater harvesting is the main component of watershed management. The best performing watersheds are those where soil erosion will reduced by more than 50 percent and the worst performing are the ones where there is an increase in soil erosion or the implementation failed in arresting soil erosion (Premsingh, *et al.*, 2011).

4. Runoff reduction

Contour bunding or field bunding has helped in checking the runoff of rainwater resulting in soil moisture retention.

5. Land use pattern, cropping pattern and agricultural productivity

(a) **Change in land use pattern:**

With available water harvesting structure farmers are inclined to new cropping pattern and agricultural diversification lead to increase in agricultural productivity.

(b) Cropping intensity

Increase in residual moisture content due to contour bunding helping in crop growth and yield. Loosening the hard strata, thus increase in infiltration of water and easy penetration of roots due to land development activities like levelling and tillage. Decrease in soil erosion and hence protection of fertile top soil due to contour bunding. Increase of ground water and supplemental irrigation due to water harvesting structures.

(c) Increase in agricultural productivity

Efforts to increase the yield of common cultivable crops by adopting: a) High yielding variety, b) Judicious use of irrigation water, c) Short duration and with low requirement of moisture level crops, d) Proper use of manures and fertilizers, e) Increase in production of milk, f) Due to increase in biomass in grazing lands and availability of fodder helped in increase of small ruminants and leads to improvement in economic status.

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IMPACT ASSESSMENT AND EVALUATION OF OPERATIONAL RESEARCH PROJECT OF AICRPDA

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Introduction

Rainfed agriculture in India is practiced in diverse agroecologies (arid, semiarid, subhumid, humid and per humid climates; diverse soil types, rainfall situations and production systems) covering about 56% of the net cultivated area, contributing 40% country's food basket with an area of 87% under coarse grain cereals and pulses, 80% of horticulture, 77% of oilseeds, 60% of cotton, and 50% of fine cereals including rice, wheat, maize, sorghum etc. Further, rainfed regions also support 60% of livestock and 40% of human population. Due to yield plateuing in irrigated agriculture, the higher agricultural production and productivity leading to second green revolution is expected in rainfed areas to ensure nutritional security and agricultural sustainability. Appropriate technologies including crop diversification; developing crop genotypes with high and stable yields coupled with abiotic and biotic stress tolerance; location specific soil and water conservation measures, alternate land use systems and integrated farming systems have to be evolved and promoted through a participatory approach. Increasing resource use efficiency for enhancing system productivity is pivotal for maintaining the productivity levels in rainfed agriculture.

All India Coordinated Research Project for Dryland Agriculture (AICRPDA)

The Green Revolution in mid-sixties, though a boon to Indian agriculture, ushered in era of wide disparity between productivity of irrigated and rainfed agriculture. Alarmed by such a situation, during Fourth Plan (1969-74), the emphasis was to focus attention on hither to neglected farmers of the dryland regions to participate meaningfully in the agricultural development process. This socio-economic imbalance led to a serious rethinking and a comprehensive network research program was initiated to stabilize the performance of the then introduced hybrids of coarse cereals in rainfed region and to moderate the periodic drought related adverse impact on total agricultural productivity. Further, droughts of mid-sixties catalyzed the Govt. to invest on dryland research significantly. In1970 the ICAR launched All India Coordinated Research Project for Dryland Agriculture (AICRPDA) at Hyderabad, in collaboration with the Canadian International Development Agency (CIDA) with 23 centres and Co-coordinating Cell at Hyderabad. At present, AICRPDA has 19 main centers, 3 subcentres, 5 voluntary centres and 8 ORP centres located in 17 states and spread in diverse rainfed agroecologies. AICRPDA is the only project with the mandate to test the technology in farmers' field. At each center, location-specific research based on natural resource management and socioeconomic status was the hallmark of the programme.

Operational Research Project (ORP)

In AICRPDA, the significant milestone was introduction of the concept of Operational Research Project (ORP) in 1976 for technology assessment, refinement and transfer. To address this, 8 ORP centres were initiated at 8 main centres viz. Ranchi, Bangalore and Hoshiarpur in 1976, Anantapur, Hisar and Arjia in 1984, Solapur in 1985 and Indore in 1986. Subsequently, the main and ORP centres at Ranchi and Hoshiarpur were shifted to Chianki and Ballowal Saunkhri.

The concept *of* Operational Research Project (ORP) was trusted feedback *to* the *research system* on adoptability *of* dryland technologies by farmers as a wing to selected centres with a CIDA financial support. ORP was recommended as an integral part *of* the existing dryland research center. The centre for ensuring continued research support and feedback to the Dryland centre administers it. Hence, the staff provided to ORP was minimal. There has been no attempt to provide staff with specialization in any particular discipline, as farmers expected to carry'}' out our recommendations without relying on *"expert"*. A feedback from Travelling Seminar Participants (AICRPDA, 1984) revealed that emphasis should be on the need for treating the technology transfer objective *of* the Dryland Project as an integral part *of* the research program. In fact, the entire dryland project is based on the assumption that research will be transferable to dryland farmers. ORP with its feedback strategy can have a strong influence on maintaining a relevant research program. The research and transfer program then must be integrally linked. The transfer programs must be rigorous in their observations, analysis and reporting because, if they lack required rigor, the scientific validity *of* the total program will suffer. Thus, *"Research* in *Operational Research"*. The specific objectives *of* ORPs are to test, adopt and demonstrate the new agricultural technologies on farmers' fields in a whole village or in a cluster *of* few contiguous villages/ watershed areas: to determine the profitability *of* the new technologies and their pace or spread among the farmers; to identify the constraints both technological and socio-economic which are barriers to rapid change; and to demonstrate group action as a method *of* popularizing modem technologies at a faster rate (Prasad and Byra Reddy,1991).Successive Quinquennial Review Teams (QRTReports 1990, 1996 and *2001)* appreciated the role *of* ORPs in rapid transfer *of* technologies by improving the research output through appropriate feedback. The approach *of* ORPs to local problems is by and large in a demonstration mode with emphasis on improving crop productivity, thus focus is commodity *oriented* while their need *of* the hour is Farming Systems oriented. Similarly, the processes adopted by ORPs have yet to tap the fullest potential *of* participative methods *of* research and extension. To this extent the approaches have been more or less top-down. The QRTs have recommended the ORPs to work on diversification *of* rainfed agriculture besides conducting participatory on-farm research on a watershed basis. The review teams have also emphasized on trials *of* soil and water conservation and groundwater recharge in ORP villages. The literature pertaining to ORPs in dryland areas is by and large confined to impact studies (AICRPDA Annual Reports, *2003).* The missing link is the information on the role *of* ORPs in the changing scenario particularly in projects like Technology Assessment and Refinement through Institute - Village Linkage Programme (NATP- ICAR, 1999-2005) that has a mandate to assess and refine the technologies.

The emerging issues/needs *vis-a vis* role of ORPs Rainfed regions are characterized by diverse agro-topo climates (arid, semiarid, subhumid and perhumid) and production systems, drought prone, fragile soil-landscape continuum with poor soil and land quality, scarcity of water (surface, subsurface and groundwater) and resource poor socioeconomic settings. The growth rate in rainfed regions was high before 1990s while it witnessed negative or zero rate during 1995to 2005. There is a general consensus that since opportunities for further agricultural growth in irrigated regions is less, the only option left is to produce more from rainfed regions in order to realize 3 to 4 per cent growth rate per annum from agriculture sector as envisaged in XI Plan (Vision2025 -CRIDA,2007). This demands more focus on enhanced utilization of natural, material, human and financial resources in rainfed agriculture. To achieve this, the approach should be a paradigm shift from *"Input and Policy centric"* during green revolution to the present *Resource Management and Policy Centric".* The research under AICRPDA network centers has been focusing to address the location specific problems considering agro ecological characteristics, predominant rainfed production systems and socioeconomic settings with specific emphasis was on soil conservation and rainwater management, evaluation of crops/varieties, cropping/farming systems and contingency planning, integrated nutrient management, tillage and farm machinery and alternate land use systems. In the last few years, more focus was given on cropping/farming systems, tillage and integrated nutrient management, alternate land use systems for diversification and efficient implements on a template of resource management particularly rainwater management.

Addressing natural resource management issues *vis-a vis* the twin problems of climate change and land degradation in rain fed agriculture is need of the hour. Emerging modern tools like remote sensing, GIS and Information Communication Technologies (ICTs) and appropriate changes in policies governing pricing and export of agricultural commodities need to be pursued rigorously. Such initiatives call for taking a close look at the situation and making required structural adjustments so as to evolve processes to enhance the effectiveness of ORP as an institution. This requires an understanding of the prevailing perceptions of ORP by different stakeholders. Creation of awareness among them about the need for a change and development of their capacity for change management. In other words, it is necessary to make sure the relevance of ORPs in these areas and to prepare them to take on the challenges in the changed local and global scenario. This necessitated studying *on* the content and approach of the ORPs so that the livelihood issues are addressed in a holistic manner while dealing with natural resource management options in rainfed agro-ecosystem. Adopting a more participative research and extension agenda will help address and integrate livelihood issues with natural resource management in this fragile agro-ecosystem.

Action Research

Action research is a group of research methodologies that pursue action (or change) and research (or understanding) at the same time. In most of its forms, it does this by using a cyclic or spiral process and alternates between action and critical reflection and in the later cycles it continuously refines the methods of data collection and interpretation in the light of the understanding the developed one in the earlier cycles. It is thus an emergent process, as it increases the understanding and an iterative process, as it converges towards better understanding of what happens. In most of its forms it is participative and qualitative. In view of this, a study was undertaken the ICAR-AP cess project on Capacity building of ORPs-An Action Research was initiated with the major objectives to build the capacity of ORP for meeting the changing needs of integrating NRM research and livelihood issues and to institutionalize a process to enhance the effectiveness of ORP. The outcome of the study is briefly presented below.

The Study processes

The study process describes the method adopted in the process of capacity building. This is a carefully planned participatory study to realize the set objectives. The entire process is divided into four phases viz. Sensitization phase, consultation and modification phase, capacity building phase, action research phase and evaluation phase.

a. Sensitization phase

A format was designed to elicit response from ORP scientists on the need to add value in terms of content and capacity to the ORPs. Once the feedback was obtained through structured questionnaire, sensitization workshop was organized for ORP scientists. Issues related to technical, financial, infrastructure, institutional, HRD and policy were discussed during the workshop.

b. Consultation and modification phase

Following the sensitization phase, a Technical Workshop was organized to discuss with ORP technical programme with the scientists from main center, ORP and CRIDA. An Expert facilitated this workshop focusing on amendments to the present ORP programmes keeping in view challenges faced by rainfed agriculture. The outcomes of the workshop are presented in relation to the objectives set out for the workshop: Link between the AICRPDA center and the ORP, Enhancing the effectiveness of ORP, Integration of NRM and livelihood issues rainfed agro eco system, and feedback.

c. Capacity building phase

In this phase, it was proposed to put the selected ORP scientists on a continuous learning and capacity-building module. There were periodical interactions and workshops for required attitudinal and behavioral changes besides the skills required to arrive at participative research and extension plan. In order to evolve new paradigm of policy research beyond technical research, analysis of technology adoption, diffusion scenario, upscaling of successful technologies etc., were needed. To fulfill these envisaged activities, the following information was sought from the ORP scientists.

First to understand the technology adoption and diffusion process in ORPs, it was felt necessary to obtain information on various *technologies that are adopted both by ORP farmers and other farmers (Category -I); technologies that are adopted by ORP farmers and not by other farmers (Category -II) and technologies that are not adopted by either ORP farmers or by other farmers (Category-III).* Category I Technologies for *Participatory Extension Plan* and for Category II and III technologies for Participatory Research Plan and Institutional analysis.

In continuation to the Sensitization Phase and Consultation and Modification Phase during the first year, it was felt that the effectiveness of ORPs depends on several factors to facilitate technology adoption amongst the farmers. It was also determined by considering whether such technologies diffused beyond target farmers i.e., other farmers in the ORP villages or farmers in the surrounding non-ORP villages. For explicit information on this, the details on technology adoption and diffusion under three categories from the 8 ORPs were given. In this phase, as suggested by the reviewers' views, one ORP i.e., Hanjagi, Solapur was selected for action research.

The scientists from the ORPs were continuously under interaction with the project team for the following purposes.

a. Modification of the technical content of the ongoing programme
b. Emphasizing both exogenous and endogenous knowledge bases
c. Extension management or local extension management by locally existing Community based organizations (CBOs/Self Help Groups (SHGs)/Village Organizations (VOs)/Panchayat Raj Institutions (PRls).
d. Evolving and building the *Support Systems* through participatory research plan to fill the gap in technology adoption. For this, much of the external assistance will be through financial arrangements like revolving funds etc.
e. Enhancing the level of diversification at family level

The characteristics of agricultural technologies and techniques to be diffused affect adoption (Napier,1990; Pearce et al, 1990; Thomaset al, 1990). Similarly, socioeconomic characteristics (ICAR,1988) (Grewal and Joshi, 1991), cultural definitions (Rogers, 1983), institutional constraints (Napier, 1991) and lack of appropriate training strategies (Chowdhary, 1991; Kidd, 1991) are the other factors that affect upscaling of technology. In order to evolve new paradigm of policy research beyond technical research, analysis of technology adoption, diffusion scenario, upscaling of successful technologies etc., were needed (RavindraChary et al., 2006). To fulfil these envisaged activities, the following information was sought from the ORP scientists.

- **For Participatory Extension Plan:** Relevant in case of Category-I technologies (Technologies that are adopted by ORP farmers and diffused to other farmers): This requires analysis of the technologies including those from other sources for upscaling. Information was sought on: successful technologies in ORP that are originated form AICRPDA Main Centre and from other source (non-AICRPDA source), successful technologies and the technologies that include one each from AICRPDA and non-AICRPDA sources with particular emphasis on natural resource management (NRM).
- **For Participatory Research Plan:** Relevant in case of Category-II (Technologies that are adopted by ORP farmers but not diffused to others farmers) and Category- III (Technologies that are not adopted either by ORP farmers or by others); Scientists from AICRPDA Main Centre analysed the reasons for non-adoption by personal interview or group discussion for a particular technology with the farmers in the ORP village and obtained details. For this, information was sought for all the technologies tried in ORP. Besides this, analysis of existing village-based institution analysis was also done to gain an understanding about the roles they could play in technology diffusion.

The details of responses on the technologies for participatory research and extension plans from 8 ORP centes was summary of the feedback was obtained in the following format.

Participatory Extension Plan

Category I-Technologies adopted by ORP farmers and not diffused to others

ORP centre	IMC	RWM	Varieties	+Practices	CS	FM	INM	WM	ALU	Total
Total										

IMC: In situ moisture *conservation; RWM-Rainwater management; practices-time of* sowing; CS-*Cropping systems;* FM-Farm *machinery; INM-Integrated nutrient management;* WM - *Weed management; ALU- Alternate Land* Use *Systems*

Participatory Research Plan

Category II-Technologies adopted by ORP farmers and not diffused to others

ORP centre	IMC	RWM	+Practices	CS	FM	INM	WM	ALU	Total
Total									

Category III - Technologies not adopted by ORP farmers or by others

ORP centre	IMC	RWM	Varieties	+Practices	CS	FM	INM	ALU	FS	Total
Total										

Analysis of technologies: The Analysis of the various categories of technologies under different themes for support systems is presented below.

- Category I technologies generally need little or no support for adoption by ORP and other farmers. They are essentially those that are ready for large scale up scaling. However, the process of up scaling them may offer important learnings relevant to institutions and policies that may be of value for dealing with category II and III technologies. Examining the kind of support required for encouraging large scale up scaling of Category I technologies will help formulate research on support systems.
- The reasons for non-adoption of technologies in Category II& III were analysed with respect to the support system in terms of research, institutions and policies. A production system-wise classification of such technologies is presented in the following matrices.

Category- II Technologies

Theme	Support system				
	Institutional	Policy	Research		Others
			Refinement	New Initiative	
IMC	Groundnut based Rice based Rabi sorghum based Maize based Pearl millet based Fingermillet based Soybean based	Pearl millet based Rice based	Groundnut based Rice based Rabi sorghum based Pearlmillet based	---	---
RWM	Groundnut based Rice based Rabi sorghum based	Soybean based Rice based Rabi sorghum based Groundnut based	---	---	---
Varieties	Soybean based Rice based Rabi sorghum based Groundnut based Fingermillet based	Soybean based Rabi sorghum based Groundnut based Maize based Pearlmillet based	Pearlmillet based	Maize based Pearlmillet based	---
Other practices	Rice based Rabi sorghum based	Maize based	Rabi sorghum based	Maize based	---
FM	Groundnut based Rice based Rabi sorghum based Maize based Pearl millet based Fingermillet based Soybean based	Maize based	Groundnut based Rice based Rabi sorghum based Pearlmillet based	---	---
INM	Soybean based	Soybean based Groundnut basedRice based	---	Rice based	---
WM	Rice based	---	Rice based	---	---
ALU	Rice based Rabi sorghum based Maize based Soybean based	Rice based Rabi sorghum based Maize based Soybean based	---	Rice based Maize based	---

FS	---	Groundnut based	---	---	Finger millet based
CS	Rabi sorghum based Maize based	Fingermillet based Maize based	Rabi sorghum based Maize based Rice based	Rice based Rabi sorghum based Fingermillet based	---

A careful look at matrix laid out for Category II technologies suggests that most technologies didnot diffuse from ORP villages to other villages because of lack of institutional and policy support.

Category – III Technologies

Theme	Support system				
	Institutional	Policy	Research		**Others**
			Refinement	New Initiative	
IMC	Groundnut based Maize based Fingermillet based Soybean based	Groundnut based Rabi sorghum based Maize based Fingermillet based	Rice based Rabi sorghum based	Rice based Rabi sorghum based Soybean based	Rabi sorghum based Maize based
RWM	Groundnut based Maize based	Groundnut based Rabi sorghum Based Pearlmillet based	Groundnut based	---	---
Other practices	---	Maize based	---	---	---
FM	---	---	Maize based	---	---
WM	---	---	---	Maize based	---
ALU	Groundnut based Rice based Maize based Pearlmillet based	Groundnut based	Groundnut based Rabi sorghum based	Rabi sorghum based Maize based Pearlmillet based	Rice based Pearlmillet based
CS	Rabi sorghum based	---	Rice based	Rabi sorghum based Rice based	---

- Category III technologies are perfect cases requiring refinement in order to be adopted by farmers. Generally, these need a re-look by the scientists keeping in view of the farmer preferences and constraints. Hence, ORP needs to bring them to the notice of the scientists working in AICRPDA main center. This can be achieved by facilitating a face to face between Main centre scientists and farmers. This will help providing direct feed back to research system.
- Category III technologies (see the matrix), also desire a greater policy and institutional commitment, particularly certain NRM technologies that involve investment in creation of physical assets for utilization of rainwater (water harvesting, recycling, farm ponds)etc. in order for the them to diffuse on a large/community scale. Equally, efforts are needed in research initiatives and refinements to the existing technologies in view of addressing changing scenario of rainfed agriculture in the respective domains. The process of refinement and diffusion can be hastened for Category II and III technologies by adopting participatory technology development process. The support required in terms of credit/input availability, knowledge/information would also help faster diffusion.
- It can be summarily inferred that the reasons for non-adoption of NRM technologies are more to do with lack of proper institutional and policy support and hence the solution for such problems does not lie in mere research. It also indicates that technology transfer in rainfed agroecosystem is not merely communicating the research outputs to farmers, but a function of creating favourable policy and institutional environment in order to facilitate higher adoption and wider diffusion. For instance, rainfed agriculture suffers from shortage of labour. Since many of the NRM technologies like community based SWC measures are labour and energy intensive, institutions such as custom hiring centres and policies like linking rural employment guarantee programmes with watershed development activities would help faster uptake of technologies.
- Most NRM technologies also need community approach for deriving tangible benefits. Therefore, there is need for arriving at community level consensus for adoption of such technologies. Women self-help groups (SHGs),Rytu Mitra Groups (RMGs like in Andhra Pradesh) could play vital role in adoption.

d. Action research phase

Once the capacity-building programme began, the action research phase also started simultaneously. During this phase, participatory research and extension plans were grounded in the fields in ORPs.

e. Evaluation phase

The project was continuously monitored during its period. However, to know the impact of the interventions made during the project a specially designed questionnaire was circulated to all the ORP centers and feedback was obtained. All the centers agreed that the interventions helped to improve the linkage between the AICRPDA main center and ORPs. Several measures were undertaken by ORP and main centers to bring about convergence with line departments, community-based organizations. This helped to improve the visibility of the work going on in ORPs and AICRPDA main centers. The ORPs began to increasingly adopt participative measures in planning process. This also helped in better implementation of the plan. More and more capacity building programmes and stakeholder engagement initiatives were taken up across the ORP centers. ORP centers addressed the necessity of diversity better by integrating livestock and horticulture with cropping. Another major contribution of the project was that the ORPs began to adopt a host of participative tools such as focused group discussions, exposure visits, field days and farmers' fairs.

I**mpact of different interventions**

The impact of different interventions on crop productivity and economic returns in different villages adopted by ORP centres, for example in the villages adopted by Arjia and Bengaluru, centres is presented in Tables 1,2& 3.

Table 1: Impact of ORP programme in adopted village of Arjia

Intervention	**Area covered (ha)/ (No. of farmers)**	**Adopters**		**Non adopters**	
		Net returns (Rs/ha)	**B: C ratio**	**Net returns (Rs/ha)**	**B:C ratio**
In situ moisture conservation	5.60/14	28650	3.16	16968	2.58
Rainwater harvesting and efficient utilization with or without MIS	41.0 /82	41718	2.91	14140	2.19
Soil and water conservation/watershed programmes	12.5/50	17750	2.08	4600	1.21
Integrated farming system – Crop- livestock (cow/ buffaloes)	48. 5 ha, 42	22045	2.58	12701	1.84

At Bengaluru, the overall adoption of different interventions ranged from 4-42% with increase in productivity ranging from 680144%. The B:C ratio with adoption of improved crop varieties was 3.0 and 3.5 with INM practices. The gross cropped area in the adopted villages increased by 21% (542.89 ha) compared to baseline year. Similarly, the cropping intensity increased from 125% to 150% in the ORP villages (Table 2&3).

Table 2: Impact of ORP programme in adopted village of Bengaluru

Agroclimatic Zone	**RWM**			**CS**			**INM**			**EV**		
Zone – 5 Eastern dry zone (ORP area)	A	P1	P2	A	P1	P2	A	P1	P2	A	P1	P2
	42	113	3.13	19	68	3.11	4	101	3.5	27	144	3.0

A= adoption; P1= increase in productivity; P2= profitability; A and P1 in % and P2 is B:C ratio

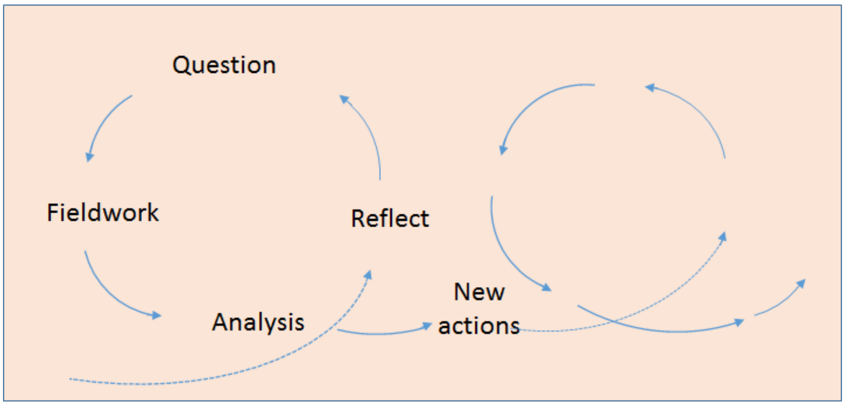
Table 3: Impact of ORP programme in adopted village of Bengaluru

Category	**Total holding size (ha)**		**Gross cropped area (ha)**		**Cropping intensity (%)**	
	(Baseline)	**(After ORP)**	**(Baseline)**	**(After ORP)**	**(Baseline)**	**(After ORP)**
Marginal	122.24	122.24	153.00	183.24	125	150
Small	180.25	180.25	225.31	270.25	125	150
Medium	56.40	59.40	70.50	89.40	125	150
Large	-	-	-	-	-	-
Overall	362.09	366.09	448.81	542.89	125	150

Impact of Action Research

The action research processes could really able to converge programmes/ schemes for implementing NRM programmes (at Arjia through DRDA, MGNREGA etc.), rainwater harvesting and reuse through farm pond technology (at Indore linking with state govt. programmes); participatory technology development linking with KVK and ATMA (at Arjia through Farmers' Field Schools), linking with CRIDA through MoRD, GOI, sponsored Farmers Participatory Action Research Programme (at Arjia, Ananatapur, Solapur and Bangalore). The tangible benefits were also observed at ORP, Ballowal-Saunkhri, ORP, Ranchi, ORP, Bangalore, where developing linkages with line departments/strengthened the ORP activities with other institutions (Ravindra Chary *et al*., 2009). This was much needed in the sense that, the technical personnel and financial resources are meager with ORPs to address the larger and emerging issues in rainfed agriculture even at a particular ORP's recommendation domain, to implement participatory technology extension and development plans. For example, natural resource management technologies like rainwater harvesting and reuse, are capital intensive, only can be up scaled by linking with ongoing programmes like watershed development, MGNREGA etc., and further need soft loans to the farmers to adopt efficient water use methods through micro irrigation etc. which need diesel pump, sprinkler/drip systems. For large upscaling of improved varieties, improved agro techniques, dryland horticulture etc., converging with national programmes like National Mission on Sustainable Agriculture (NMSA), National Food Security Mission (NFSM), Rashtriya Krishi Vikas Yojana (RKVY), National Horticulture Mission (NHM), PMKSY (Pradhan Mantri Krishi Vikas Yojana) etc. and state programmes like Krishi Bhagya of Karnataka etc. would be complementary and very effective in achieving the mandate of ORPs. Further, promoting seed village programmes, capacity building of farmers linking with ongoing programmes of KVKs, ATMA, SAMETHI, and NGOs etc. would largely benefit both the farming communities and ORPs to enhance participatory extension plans.

The process of capacity building under the action research /learning cycle the project has also largely adopted the action learning process (shown in figure). Thus, this process is now ingrained in the minds of the stakeholders. This will go a long way in sustaining the spirit of action research beyond the conclusion of this project.



The action research/learning cycle

Conclusion

The action research in rainfed agriculture areas needs redefining the approach with prioritized programme planning, effective implementation, monitoring and evaluation. For wider upscaling and scaling out of the rainfed technologies, the action research programmes should be linked with the ongoing local schemes/programmes of state/central governments. A convergence approach with the research, education and extension programmes of the local institutions/agencies/organizations/communities engaged in rainfed agriculture development is essential. Further, policy research on support systems is needed i) to find out which kind of community organizations are ideal for upscaling Category-I and II technologies; ii) for which type of financial incentive is required for adoption and retention of Category I and II technologies, whether revolving funds, bank loans or contributory approach; iii) whether the technologies that are not being adopted for want of labour would be adopted if and only labour was made available and iv) to think about such technologies, that emerge out of informal research and document the outcome of such research, for validation and upscaling.

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